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ENVIRONMENTAL IMPACT ASSESSMENT STUDY FOR ARMY MILITARY PROGRAMS

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Champaign, Illinois

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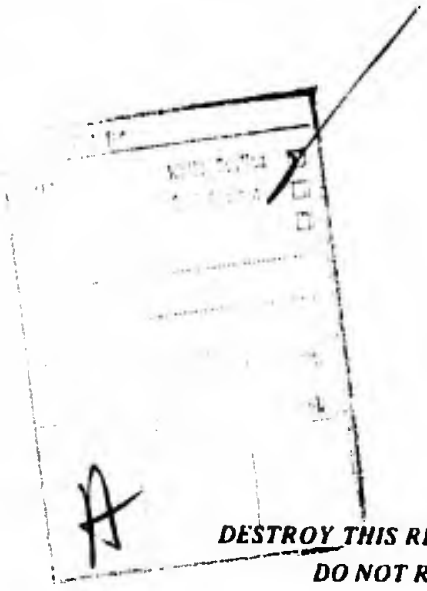

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This report presents the research to date on the development of systematic procedures that can be used by personnel at all levels of the Army to prepare and review realisitc and meaningful environmental impact assessments and statements for Army military programs.

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Army programs were grouped into the Army functional areas of construction, research and development, real estate acquisition or outleases of land, mission change, procurement, training, administration and support, industrial activities, and operation, maintenance and repair. A systematic procedure was formulated whereby basic activities associated with implementing Army programs were developed for each functional area.

A computer-aided assessment system was developed for identifying potential environmental impacts by relating the Army activities from the functional areas to attributes contained in eleven technical areas of specialty utilized to describe the environment. Three levels of attributes were developed: (1) detailed level; (2) review level; and (3) controversial attributes. Ramification remarks regarding potential construction impacts were developed along with mitigation procedures for minimizing adverse impacts:

SUMMARY

1 INTRODUCTION

Background. Nearly 100 years ago the California naturalist John Muir expressed alarm at the way in which the demands of modern living had led to visible degradation of wilderness environments across the United States. Only recently has similar concern led to broad, nationwide legislation designed to protect the human environment. The various pollution control laws are common examples of this type of legislation.

One of the most important and far-reaching of these laws is the National Environmental Policy Act of 1969 (NEPA). It requires broad consideration of all aspects of the human environment during the planning and implementation of programs by all federal agencies. Presidential Executive Order 11514, issued in 1970, goes one step further, requiring federal agencies, including the Army, to do more than just comply with the letter of the law in following NEPA. They are required to take the lead in originating programs which enhance the environment, rather than simply minimizing further degradation.

Specifically, NEPA and subsequent guidelines established by the President's Council on Environmental Quality require an agency to assess each major program it wishes to implement. When it became clear that a very large number of new and continuing actions of the Army were covered by NEPA, no assessment procedures existed. Although interim procedures have now been implemented in many commands, with varying success, unified and comprehensive procedures for preparing, documenting and reviewing realistic environmental impact assessments and statements are still in their infancy.

Requirements of NEPA. The basic requirement made of federal agencies by NEPA is that of an initial environmental impact assessment (EIA). This is construed as a complete look at all aspects of the proposed action, pointing out those places where environmentally related problems are expected to arise. While this document has no prescribed format and is mainly for intra-agency circulation, a format similar to that of the environmental impact statement is recommended. The EIA may, however, be a required attachment to requests for funding for the project or actions, and some agencies, including the Army, may delay allocation of funds if the assessment is felt to be incomplete or unrealistic. The assessment must answer the questions:

1. Will the program significantly affect the quality of the human environment?

2. Will this effect on the environment be controversial?

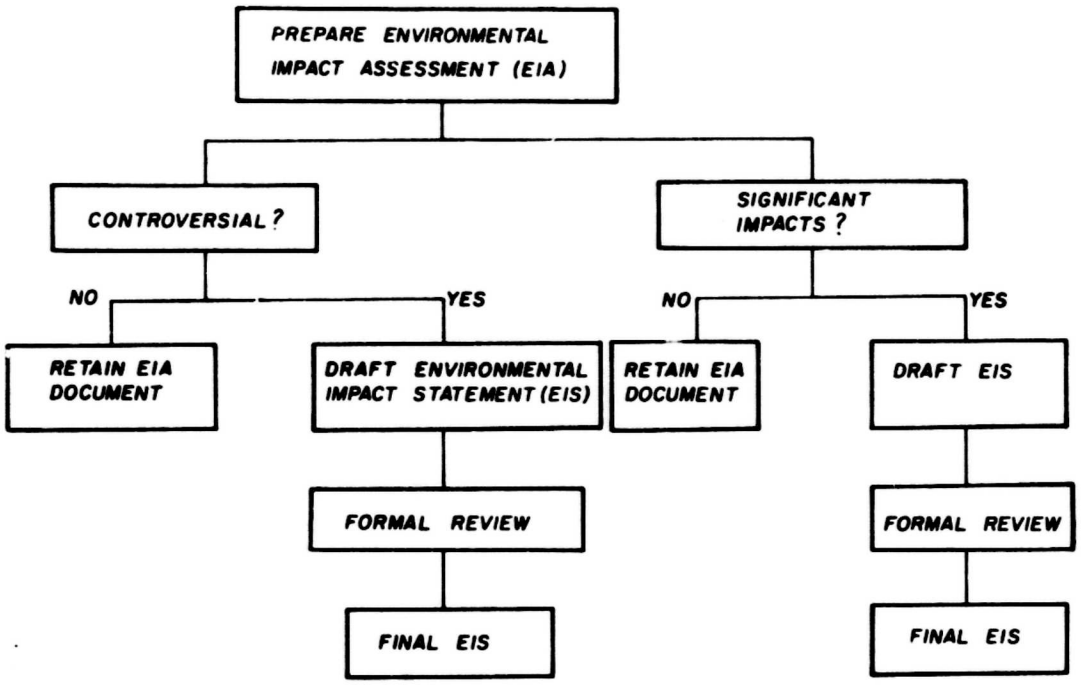
If the answer to either question—obtained through an honest, complete assessment of all aspects of the project, including secondary effects—is "yes," the proponent agency must prepare a formal environmental impact statement (EIS). Summary Figure 1 shows the relationship between an EIA and an EIS. The contents of the EIS are formally delineated by law; the Council on Environmental Quality has prescribed the following organization:

1. A description of the proposed action
2. Statement of probable impacts on the environment
3. Description of adverse impacts which cannot be avoided
4. List of alternatives to the action
5. Relationship between short-term and long-term use of the environment
6. Discussion of irreversible and irretrievable committments of resources
7. Discussion of problems and objections raised by others.

While any agency can relatively easily gather the descriptive material necessary to explain the location and purpose of a project or action, most of the other parts of the EIS require specialized assistance. In recognition of this deficiency, the Construction Engineering Research Laboratory (CERL) of the Corps of Engineers was requested to undertake a comprehensive research program leading to an improved methodology for completing this requirement. This program was funded late in FY 72; the interim report summarized here presents the results of this program through December, 1972.

2 ORGANIZATION OF STUDY

It is the objective of this study to develop systematic procedures which may be used by personnel at all levels within the Army to prepare and review environmental impact assessments and statements. Most persons think an assessment is needed only for major construction of new facilities, but many other Army programs require assessments. Conduct of training exercises, changes in mission of a base, pest control programs, and disposal of excess property are some examples of common actions which may require assessment. Because of the wide



Summary Figure 1. Flow of environmental impact assessments and statements and their interrelationship.

variety of Army military activities and the complexity of associated environmental effects, a major portion of the initial effort in this study was directed to questions of categorization of these activities and effects.

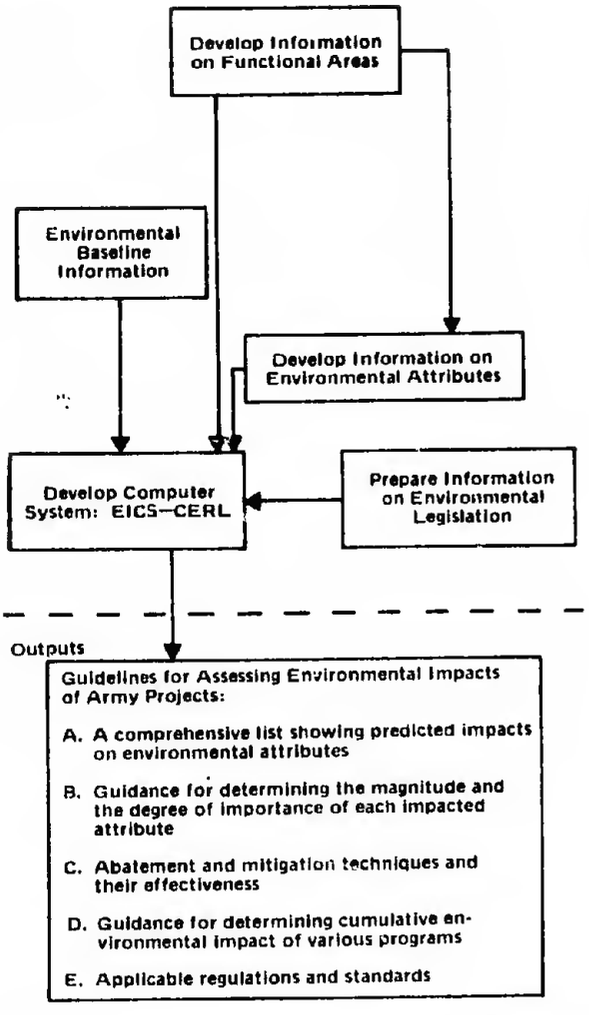
The first major task was to study the nature of Army activities. The second phase was devoted to organizing and categorizing the elements or attributes of the biophysical and socioeconomic environment which might be affected by the activities. The third aspect of the program dealt with accession of appropriate state and federal legal requirements and constraints which might affect proposed actions. Summary Figure 2 shows the overall plan of study.

Army Activities. Many possible aggregations of activities are possible when examining Army military programs. Fiscal codes identify spending elements in great detail. Different commands deal with different basic functions while retaining some activities in common. Inventory classifications provide a slot for almost every conceivable facility. None of these proved to be of the level of simplicity needed as a basis for this study.

After consultation with Army personnel and review of existing guidance, a new classification was developed which was a synthesis of several approaches. This organizes Army activities into nine functional areas:

1. Construction
2. Operation, maintenance and repair
3. Training
4. Mission change
5. Real estate
6. Procurement
7. Army industrial activities
8. Research, development, test and evaluation (RDT&E)
9. Administration and support.

By definition, including a rather arbitrary assignment of certain programs to specific areas, these nine general areas encompass all Army military activities in the continental United States. Within each functional area basic activities were further identified. A Basic Activity associated with implementing an Army Program (BAAP) was defined at a relatively detailed level. Some examples of BAAPs in the construction functional area include clearing trees, removing broken concrete, backfilling foundation, curing bituminous pavement, cleaning used concrete forms, installing insulation, and landscaping site.



Summary Figure 2. Generalized study scheme.

Approximately 2000 BAAPs have been tentatively identified in all nine functional areas. The complexity of a particular area determined the detail of a BAAP. In many cases, alternative methods of accomplishing an action have different environmental effects. Where applicable, such alternatives were sought out and included.

Each of the nine Army functional areas is discussed in detail in the main report, although construction is emphasized. Examples are given of the nature of impacts expected to be caused by the activities in each area, as well as references to some of the important Army publications examined in developing that area. A number of representative BAAPs are listed for each functional area.

Environmental Attributes. While the development of the BAAPs was accomplished by CERL personnel and consultants from within the Army, an interdisciplinary team of scientists was assembled to identify environmental attributes. Twenty scientists contributed their expertise in fields as varied as zoology, noise pollution and groundwater. During five interactive sessions in the summer of 1972 the basic outline of the study was implemented and further defined.

The system which evolved divided the environment into 11 broad areas or technical specialties:

1. Ecology
2. Health Science
3. Air Quality
4. Surface Water
5. Groundwater
6. Sociology
7. Economics
8. Earth Science
9. Land Use
10. Noise
11. Transportation.

Within each of these areas the scientists developed three types of factors, or attributes, which they felt were significant.

Detailed attributes were the finest level of separation within each area. For example, in the area of Ecology detailed attributes included Rare or Endangered Animal Species, Food Webs, Warm Water Fishing and Noxious Weeds; in the area of Surface Water: Turbidity, Biochemical Oxygen Demand, Phosphorous and Mercury; and in Sociology: Residence Distribution, Ethnic Composition, Landscape Amenities and Conflicting Land Uses. Obviously, there is interaction between these areas, and the pollutants affect many types of uses of the environment, not just one at a time. About 1000 detailed attributes have been developed at this time for all scientific disciplines.

Review level attributes are broader and more inclusive in scope than detailed level attributes, but are not necessarily simply aggregations of the lower level. Some potential users of the completed system need the sort of overview which this smaller number of more important attributes will provide. Examples of review level attributes are: Resource Base, Pathogenic Organisms, and Increase in Undesirable Species—from the areas of Sociology, Surface

Water, and Ecology, respectively. About 100 review level attributes are currently utilized.

Controversial attributes identify those areas which the scientists feel will arouse public opposition to a proposed program. Scientifically, they may not represent the greatest environmental threats, but may merely be particularly sensitive areas. Impacts on Game Animals, Oil Spills and Amenity Elements are three examples from Ecology, Surface Water and Sociology, respectively. About 50 particularly sensitive areas were identified.

The large number of attributes caused an "information gap," since the complete meaning of an attribute of the environment may not be always inherently clear from its name. It was felt that users might have difficulty synthesizing the relationships needed. As a result, another item of output—a descriptor—was created.

A descriptor, as used in this study, is a four-part explanation of the detailed level attribute. It contains in relatively non-technical language the information needed by the user to understand the nature of the attribute as well as its relation to other attributes, environmental factors, and man. The four parts, labeled A, B, C, and D, are:

A. A simple definition of the term, often including examples.
B. Further explanation of the importance of this attribute, usually including the ways in which man's activities affect it.
C. Identification of the source of the pollutant or examples of the manner in which Army activities impact the attribute.
D. Interactions of this attribute with other attributes, including some judgments as to its relative importance.

Examples of descriptor packages are shown in Summary Figures 3 and 4.

Four-part descriptor packages were not prepared for review level and controversial attributes. Instead, a narrative paragraph incorporating most of the above ideas in non-technical language was prepared for each of these more inclusive items. These descriptors and descriptive paragraphs are available to assist users of the system in preparing assessments of their actions. The definition, by itself, is also available through the computer memory for immediate clarification of the nature of an attribute which is declared to be impacted.

The main report discusses each of the 11 technical specialities. Included are the full text for each review level and controversial attribute and several examples of descriptor packages for each discipline. A diagram gives the relationship between the aggregations of attributes within a specialty.

Environmental Legislation. Since under Executive Order 11514 the Army must voluntarily comply to reasonable state and local environmental regulations, a compilation of such laws is needed. A computerized environmental legislative data system is being developed concurrently with other aspects of this study. This data system is to be organized to permit users to obtain data on laws and regulations relevant to their needs. At this time federal legislation and laws from six representative states have been abstracted and accessioned. CERL is preparing a separate report on this system.

3 PREDICTION OF IMPACTS

After the general nature of Army activities for each area was explained to the assembled scientists, they began to examine each activity in detail. Each activity was compared to each attribute of the environment to determine, to the best of each scientist's ability, if the performance of a specific activity would adversely affect a specific attribute. These comparisons brought up many questions with respect to the exact method of carrying out an activity in different situations.

If trees are to be cleared from a site, for example, their size makes a difference in predicting the impact of the action. The area which remains is damaged less by individual cutting with a chain saw than by bulldozing. Less erosion and siltation results if the site is level than if it is on an appreciable slope. Fewer persons are outraged if most of the site is left forested than if the trees removed were the only large trees for many hundred yards. All these questions of degree and relativity led to the creation of three more sections of the main study: ramification remarks, mitigation procedures and baseline data. (Each will be discussed in the following section.)

Each potential impact was placed in one of four categories:

A. This potential impact must be assessed every time the activity is carried out.
B. This impact is usually present, but may be omitted depending on individual circumstances.

LARGE MAMMALS

A. Large mammals are those nondomesticated mammals whose adult weight is at least 15 kg. Deer, elk, moose, bear, and pronghorn are common examples. Most large mammals are occasionally to regularly hunted (see Hunting—Big Game).

B. Virtually all large mammals are, or have been, vastly reduced in numbers by modern civilization. Almost the only exception to this is the white-tailed deer, whose numbers are as great as or greater than in prerevolutionary times. The abandonment of marginal farmlands has created much suitable habitat for this one species.

C. Almost any occupancy of an area by man, as for bivouacs, maneuvers, firing ranges, or construction can cause large mammals to leave an area. Fire or lumbering operations may cause a shift in the species occupying an area, although they are not of themselves permanently destructive of animal populations.

D. Most large mammals are very important members of their ecosystems. They are conspicuous to the general public in addition to being the basis for a large hunting activity. Many large animal species are scarce in much of their former range and some may be classed as rare or endangered.

Summary Figure 3. Example of a descriptor package taken from the Ecology functional area.

TURBIDITY

A. The turbidity of water is a measure of the degree of interference with light transmission caused by the presence of suspended solids. It is determined both by the number of particles in the water and by the characteristics of the particles. Turbidity is measured by observing the attenuation of a beam of light passing through a water sample. Conventionally, it is expressed in empirical "units" or "Jackson Turbidity Units" equivalent to the interference to light transmission caused by 1 mg/l of a standard suspension.

B. Water quality considerations which affect the amount of solids suspended in water (see "Suspended Solids") also affect turbidity.

C. Common sources of turbidity in natural waters are clay and silt particles, organic debris, microorganisms, and similar materials. Common man-made sources include accelerated erosion, dredging, domestic and industrial wastes, and bacterial and algal growths stimulated by waste discharges. In ground waters turbidity often results from high entrance velocities to wells (over pumping) or poorly constructed wells; shaking of the ground also may result in increased turbidity.

D. Reduction of the clearness of water because of turbidity might significantly alter the ecology of a stream by reducing algal and plant photosynthesis. Aesthetic enjoyment of surface waters also may be diminished by increased turbidity. Recreational suitability, especially for swimming, likewise is reduced. Whereas turbidity normally has no direct health effect on human consumers, low turbidity in drinking water is desirable for aesthetic reasons. Also, the suspended solids causing turbidity may harbor pathogenic organisms, and turbid waters may be avoided for clear, but less safe sources. Some industrial water uses (for example, brewing and soft drink bottling, textile manufacture, papermaking, and boiler feed water) have particularly low turbidity requirements. Thus, an increase in turbidity might increase water treatment costs for downstream municipalities and industries.

Summary Figure 4. Example of a descriptor package taken from the Surface Water functional area.

C. This impact arises in a small but predictable number of cases. Consider it to see if it is present in your case.

O. (blank) There is usually no impact upon this attribute by this activity.

The A, B, C, and "blank" markings are called the "need-to-consider" scale. Provision is also made for cases where a beneficial effect arises from the impact of an activity upon an attribute, although this occurs rarely except in Economics and Sociology.

Since there may be 50 to 100 or more attributes in a technical specialty which are compared to hundreds of activities in one functional area, the number of possible intersections with impacts is very large. In the CERL Environmental Impact Computer System (EICS), these impacts are stored in the memory banks of a computer. This storage allows for rapid updating of the system, correction of errors, and inclusion of totally new types of impacts as they become known to the scientific community.

The user of the system cannot profitably use a complete list of all impacts identified by the interdisciplinary team. He is interested in those impacts expected to be caused by the particular action he is contemplating. Impacts of vehicle maneuvers are irrelevant if he wishes to construct a new classroom building. For first stage operation of the CERL system, construction-related impacts will be implemented. Within the general area of construction, 40 sub-areas were delineated and based on facility class code to comprise the majority of current construction projects. CERL personnel determined which of the construction activities were used in performing each of these types of projects. Thus, certain groups of activities are associated with certain types of projects. Extraneous prediction of impacts is thereby reduced.

The EICS functions as follows: A user identifies his project and/or gives its facility class code as set forth in Army Regulation (AR) 415-28. Certain impacts are associated with each construction activity, and the program searches out all those impacts caused by activities utilized in performing a type of project. For example, although steel fabrications by welding and riveting are activities not considered in construction of family housing, they are included in construction of maintenance shops. Thus, impacts associated by the scientists with steel fabrication will not appear in the output if the project is one for family housing.

At present, the computer output is in a matrix format, listing impacting activities on one axis and impacted attributes along the other. The "need to consider" marking appears at their intersection. The attributes may include all levels, or, at the user's option, only the review level. Controversial attributes are printed in all cases.

One of the early problems uncovered by the scientists was that of the danger of overgeneralizing about impacts. In addition, potential users of EICS might be unable to see exactly why a particular activity impacted a certain attribute of the environment. The *ramification remark* helps solve both these problems. In the former example, a scientist feeling that a very serious impact might take place, but only in certain parts of the country, wrote a short statement indicating that this impact will arise only in areas of high humidity and precipitation. This statement is keyed, in the computer memory, to the intersection which stores the marked impact. Thus, many severe impacts may be marked with an "A" even though the problem may never arise in some regions of the country.

Another use of the ramification remark is to explain the nature of an impact, especially if it is an indirect or delayed result of an activity. The descriptor package may also be called into use to explain such indirect impacts. Thus a ramification remark may call attention to the fact that the reason grading a parking lot impacts fish populations is due to erosion of the bare soil, subsequent turbidity of the water, and eventual siltation of breeding sites on the lake bottom.

When approaching the initial question of predicting impacts, the scientists also felt the need to explain that the technique utilized was often as important as the basic activity. They had many suggestions for safer ways to perform many of the operations under discussion. One of the outcomes of these suggestions was the inclusion of *mitigation procedures*. These are also stored in the computer memory, keyed to the activity to which they pertain. The system user will receive pertinent statements as to how to minimize the adverse impact predicted by the scientist. In the example of the erosion from the graded site mentioned above, construction of a check dam or temporary settling pond could be recommended.

One question raised by the scientists had no real answer. How are we to know what impact is likely if

we don't know exactly what is present on the site in the first place? In an attempt to answer this question, a separate effort was organized (to run concurrently with the main project) to collect a systematic body of *baseline data* about all major installations. The methodology for this project is complete, and data collection is underway in several areas, notably Economics, Human Health and Noise.

4 CONCLUSIONS

This is an in-depth study which will lead to systematic procedures useful to Army personnel at all levels to prepare and review environmental impact assessments and statements for all types of Army programs. Given the appropriate information for a construction program, the computer-aided system developed here will now output environmental impact assessment information which includes:

1. A list of environmental attributes which are predicted to be impacted by the project.
2. Indication of which activities within the project will impact which environmental attributes, and at what level.
3. A descriptor package describing the impacted attribute in detail.
4. Information on mitigation techniques which may minimize most of the predicted impacts.
5. Indication, through identification of controversial impacts, of those portions of the project most likely to arouse public controversy.
6. Through the environmental legislative data system, an indication of which laws and regulations are likely to affect planning of the project.

This system is in the process of being expanded to include similar detailed information for areas of Army activity other than construction.

The output from this system may be used, in conjunction with the appropriate users' manual, by facility engineers at the installation level and by planners in Corps district and division offices to prepare environmental impact assessments and statements. The information can also be used by an outside consultant. In either case, the cost of preparing a really comprehensive assessment will be greatly reduced.

A major contemplated use for the system is by persons in the upper level of the administrative hierarchy who are required to review and judge the adequacy of existing assessments and statements. Since these persons generally do not have ready access to the scientific expertise necessary to evaluate statements, the CERL system could rapidly provide them with a comprehensive prediction of expected impacts. Alternatives to the original project might also be examined early in the planning stage to determine which of them would have fewest and least serious impacts.

The system will not make judgments as to the relative importance of impacts, should they occur. It does point out which ones may be expected. The decision as to which alternative is most desirable is still an administrative one. It is CERL's hope that such decisions may be assisted by the availability of this comprehensive system.

FOREWORD

This project was performed for the Directorate of Military Construction under Project 4A162121A896 "Environmental Quality for Construction and Operation of Military Facilities," Task 01, "Environmental Quality Management for Military Facilities," Work Unit 001, "Procedures for Evaluating Environmental Impacts of All Army Military Programs." Mr. V. J. Gottschalk served as the OCE Technical Coordinator.

This study of the environmental impact of Army military programs has resulted in three reports. This main report includes general environmental impact procedures, examples of typical activities associated with implementing Army programs, and background information regarding the various scientific dsiciplines necessary to define environmental impact. The information presented in this report may be used in conjunction with the output from the computer system.

The second report, covering the environmental impact computer system, is in publication. This report includes the details of the environmental technical information system, the programming language interface developed for the study, and a typical example of computer input and output.

The third report covers selected federal and state environmental laws, regulations, and standards. Assembled with attention to the specific needs of the Army, this information is stored in a computer-accessible data bank, with provision for continuous updating.

The work which led to this report was the result of interdisciplinary cooperation between personnel of the U.S. Army Construction Engineering Research Laboratory (CERL), other Army personnel and a team of scientists assembled for this study. Following is the composition of the scientific team:

Interdisciplinary Team of Scientists for the Study

Dr. C. S. Alexander (Earth Science) University of Illinois, Urbana, Illinois; Dr. H. E. Balbach (Plant Ecology and Overall Review) U.S. Army CERL-SPE, Champaign, Illinois; Dr. F. A. Bazzaz (Plant Ecology) University of Illinois, Urbana, Illinois; Dr. C. R. Bragdon (Noise Pollution) Georgia Institute of Technology, Atlanta, Georgia; Mr. K. Cartwright (Groundwater Quality) Illinois State Geological Survey, Champaign, Illinois; Dr. M. L. Davis (Sanitary Engineer and Overall Review) U.S. Army CERL-ESN, Champaign, Illinois; Dr. N. J. Demerath (Sociology) Washington University, St. Louis, Missouri; Dr. R. I. Dick (Surface Water Quality) University of Delaware, Newark, Delaware; Dr. N. L. Drobny (Environmental Engineer Overall Review) Battelle Columbus Laboratories, Columbus, Ohio; Dr. M. A. Goodrich (Population Zoology) Eastern Illinois University, Charleston, Illinois; Dr. I. I. Holland (Land Use and Resource Management) University of Illinois, Urbana, Illinois; Dr. R. K. Jain (Noise Pollution and Overall Review) U.S. Army CERL-SPE, Champaign, Illinois; Dr. E. Y. S. Lee (Computer System) U.S. Army CERL-SPE, Champaign, Illinois; Mr. T. A. Lewis (Earth Science and Overall Review) U.S. Army CERL-SPE, Champaign, Illinois; Dr. E. W. Novak (Environmental Health Science and Noise Pollution) U.S. Army CERL-SPE, Champaign, Illinois; Dr. J. F. Nunamaker (Information Science) Purdue University, West Lafayette, Indiana; Dr. E. Romanoff (Regional Economics) Regional Science Research Center, formerly at Harvard University, Cambridge, Massachusetts; Mr. A. A. Rula (Military Transportation) U.S. Army Waterways Experiment Station, Vicksburg, Mississippi; Mr. G. S. Stacey (Economics) Battelle Columbus Laboratories, Columbus, Ohio; Dr. J. J. Stukel (Air Quality) University of Illinois, Urbana, Illinois; Dr. R. W. Thorpe (Transportation) Regional Science Research Center, Cambridge, Massachusetts; Dr. L. V. Urban (Water Quality and Overall Review) U.S. Army CERL-SPE, Champaign, Illinois.

The Army contact points who participated actively in the study include Mr. V. J. Gottschalk (OCE Technical Coordinator for the study), MAJ J. Gregg (OCRD), Mr. R. W. Ragan (TRADOC), and LT V. Smith (DALO-INE).

CERL scientists participating actively in the study, in addition to the CERL personnel mentioned in the list of scientists and authors include Messrs. W. J. Mikucki, S. E. Kloster, O. E. Rood, B. C. Goettel, and G. W. Schanche. Mrs. Esther Lee assisted in the development of the computer system.

Administrative support and counsel provided by Dr. R. M. Dinnat, Dr. L. R. Shaffer, LTC R. E. Flickinger, and COL R. W. Reisacher (Director, CERL) are gratefully acknowledged.

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FIGURES

TABLES

ENVIRONMENTAL IMPACT STUDY FOR ARMY MILITARY PROGRAMS

1 INTRODUCTION

"By virtue of the authority vested in me as President of the United States and in furtherance of the purpose and policy of the National Environmental Policy Act of 1969. . .it is ordered (that) the Federal Government shall provide leadership in protecting and enhancing the quality of the Nation's environment to sustain and enrich human life. Federal agencies shall initiate measures needed to direct their policies, plans and programs so as to meet national environmental goals." (Executive Order 11514, Protection and Enhancement of Environmental Quality, March 5, 1970).[1]

Among the first administrative actions of the President in 1970 was the signing, on January 1, 1970, of the National Environmental Policy Act (NEPA) of 1969.[2] The symbolism of the timing did not go unnoted by the President, who eralded the 1970s as a decade of environmental concern.

The significance of the legislation can best be assessed by examining developments during the time since its enactment. As summarized recently by the Council on Environmental Quality (CEQ),[3] five beneficial effects of NEPA have been:

1. To bring national policies in line with modern concerns for the environmental quality,

2. To provide a systematic way of dealing with problems which transcend the parochial interests of individual agencies,

3. To open governmental activities to public scrutiny,

4. To staff governmental agencies with personnel competent to undertake the interdisciplinary approach required by NEPA, and

5. To allow for citizen suits to provide the enforcement incentive lacking from the Act itself.

It must be noted that NEPA and its implementation have not been without their critics (as, perhaps, typified by an article entitled "Dodging the Crisis").[4] Considerable litigation has developed concerning compliance with (or, in the view of some, circumvention of) the provisions of the Act. Notable among these was the "Calvert Cliffs Case"[5] in which the courts held that compliance with established environmental standards did not relieve a governmental agency from the NEPA requirement of considering all environmental factors in assessing impact. In this case, the Atomic Energy Commission had sought to exclude water quality considerations from its assessment of the impact of a nuclear power plant on the grounds that a state had certified compliance with water quality standards under the relevant federal water pollution control legislation. Among the frequently voiced concerns about NEPA[6] are: that impact statements are not available in time to accompany proposals through review procedures; that statements are prepared in "mechanical compliance" with NEPA; that impact statements are biased to meet the needs of predetermined program plans; that agencies may disregard the conclusions of adverse impact statements; that CEQ lacks authority to enforce the intent of NEPA; that intangible environmental amenities are being ignored; that secondary effects are being ignored; and that inadequate opportunity is available for public reaction.

Perhaps the most severe of these reservations concerning NEPA were summarized by Roger C. Crampton[7] who testified that "the agencies must guard against a natural but unfortunate tendency to let the writing of impact statements become a form of bureaucratic gamesmanship, in which the newly acquired expertise is devoted not so much to shaping the project to meet the needs of the environment, as to the shaping of the impact statement to meet the needs of the agency's preconceived program and the threat of judicial review." Perhaps the point which should be made is that not only is the impact statement not a justification for a preconceived program,

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[1] "Protection and Enhancement of Environmental Quality," Executive Order 11514 (35 Federal Register 4247, March 1970).

[2] National Environmental Policy Act of 1969 (PL 91-190; 83 Stat 852).

[3] *Environmental Quality*, Third Annual Report of the Council on Environmental Quality (U.S. Government Printing Office (USGPO), August 1972).

[4] P. Ehrlich, "Dodging the Crisis," *Saturday Review*, Vol. 53, No. 11 (November, 1970) page 73.

[5] Calvert Cliff's Coordinating Committee vs. Atomic Energy Commission, 499 F. 2nd 1109, 2ERC1779, 1ELR2036, D.C. Cir 1971 (West, 1971).

[6] *CF Letter* (The Conservation Foundation, May 1972).

[7] R. C. Crampton, Testimony before Joint Meeting of the Interior and Public Works Committees of U.S. Senate (March 7, 1972).

but also it is a full disclosure of all the potential environmental impacts of importance either to the Army or to anyone else who will be affected.

Historical Background and Scope of the Study. In September 1970 the Adjutant General (TAG) published the Deputy Chief of Staff for Logistics (DCSLOG) Interim Guidelines on Environmental Impact Statements.[8] After a year's experience operating under these and subsequent quidelines, the DCSLOG evaluated the success of the implementation of the program. Several deficiencies were noted which were resolved by the issuance of the TAG letter of 21 October 1971.[9]

Four deficiencies prevented compliance with guidelines. These were as follows:

1. Lack of interdisciplinary expertise required to prepare a meaningful environmental impact assessment;

2. Insufficient manpower and funds to commit to the task of preparing the assessment;

3. Inability to account for cumulative and/or secondary effects on the environment in the assess ment process; and

4. Insufficient technical expertise at the management level to use and/or perform a realistic review of assessments made by subordinate elements.

In October 1971 the DCSLOG requested that the Corps of Engineers draft a research proposal which would outline the development of a method to alleviate these deficiencies. The Construction Engineering Research Laboratory (CERL), as the Corps of Engineers "lead laboratory" for environmental research, was in turn requested to prepare the proposal.

The CERL proposal outlined a phased program of research to resolve the deficiencies. The first phase of the program was to perform an interdisciplinary overview of all Army functions and to develop a detailed methodology for one area of Army activity. Hereafter, these areas will be referred to as functional areas. The initial selection of the functional area for detailed evaluation was made by DCSLOG. They suggested that research, development, test, and evaluation (RDT&E) be used as a test case.

Initial funding for the project was made in May 1972. In July 1972 the funds for the project were supplemented from the CERL environmental research program and the study was made a part of the overall environmental program at CERL.

Later in August 1972, in consultation with the Office of Chief of Engineers (OCE), the functional area for detailed study was changed to "construction." Two major factors led to this recommendation. The first is that construction is much more visible to the public and of greater environmental concern than RDT&E. The second reason was that generalization could be much more easily accomplished for construction than it could be for RDT&E which is highly case dependent (no two experiments are alike) and is often ill defined.

This report covers the results of the first phase of the research effort. Further work will be carried out to field test the methodology for application to the construction functional area. In the coming years detailed methodologies will be developed and tested for each of the other functional areas described in the following chapters of this report.

In succeeding chapters problem statement, summary of NEPA, and objective of this study are presented.

Problem Statement. The National Environmental Policy Act (NEPA) of 1969 (Public Law 91-190) and Executive Order 11514, "Protection and Enhancement of Environmental Quality," 5 March 1970, require all federal agencies to assess the environmental impact of implementing their major programs and to take the lead in environmental protection. Each environmental impact assessment (EIA) must answer:

1. Will the program have a significant adverse effect on the quality of the human environment?

2. Will the adverse effect on the environment be controversial? If the answer to either of these two questions is yes, the proponent agency must prepare an environmental impact statement (EIS). Procedures and information necessary for preparing, reviewing, and documenting realistic environmental assessments and statements are in their infancy.

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[8] TAG Letter, AGDA(M) (10 Sept 70), LOG-C-PDBB-8316-B, 11 Sept 70, subject: Interim Guidelines on Environmental Statements, RCS OSD-(OT) 1570.

[9] TAG Letter, DAAG-PAP(M) (1 Sept 71), DALO-IN; 21 Oct 1971, subject: Environmental Considerations in DA Actions, RCS DQ-H&E (AR).

The National Environmental Policy Act. Since requirements of NEPA form a basis for most of the research effort in environmental impact assessment, information is presented here regarding NEPA as it relates to Army programs.

Title I of NEPA sets forth the national policy on restoration and protection of environmental quality and Title II establishes the Council on Environmental Quality (CEQ) as an environmental advisory body for the executive office. In Title I, the sections relevant to environmental impact assessment are Sections 101, 102, and 103.

Requirements of Section 101 are of a substantive nature. Under this section the federal government has a continuing responsibility, . . . "consistent with other essential considerations of national policy, . . ." to minimize adverse environmental impact and to preserve and enhance the environment as a result of implementing federal plans and programs.

Section 102 requirements are of a procedural nature. Under this section the proponent federal agency is required to make a full and adequate analysis of all environmental effects of implementing its programs or actions.

Section 102 (2) (A) requires that "a systematic and interdisciplinary approach. . ." be used to insure the integrated use of social, natural, and environmental sciences in planning and decision making.

Section 102 (2) (B) says that federal agencies shall, in consultation with CEQ, identify and develop procedures and methods such that "presently unquantified environmental amenities and values may be given appropriate consideration in decision making. . ." along with traditional economic and technical considerations.

Section 102 (2) (C) sets forth the requirements and guidelines for preparing environmental impact statements. Specific format, coordination, instruction, and approval and review hierarchy are established by each element of the Army. Persons preparing an EIS should follow the instructions of their organization. Presented herein is the content for an EIS as recommended by CEQ.[10] The contents should cover:

1. A *description of the proposed action* including information and technical data adequate to permit a careful assessment of environmental impact by commenting agencies. Where relevant, maps should be provided.

2. *The probable impact of the proposed action on the environment,* including impact on ecological systems such as wildlife, fish, and marine life. Both primary and secondary significant consequences for the environment should be included in the analysis. For example, the implications, if any, of the action for population distribution or concentration should be estimated and an assessment made of the effect of any possible change in population patterns upon the resource base, including land use, water, and public services, of the area in question.

3. *Any probable adverse environmental effects which cannot be avoided,* such as water or air pollution, degradation of air or water quality even though in compliance with laws, undesirable land use patterns, damage to life systems, urban congestion, threats to health, or other consequences adverse to the environmental goals.

4. *Alternatives to the proposed action.* NEPA requires the responsible agency to study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources. A rigorous *exploration and objective evaluation of alternative actions* that might avoid some or all of the adverse environmental effects is essential. Sufficient analysis of such alternatives and their costs and impacts on the environment should accompany the proposed action through the agency review process in order not to foreclose prematurely options which might have less detrimental effects.

5. *The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity.* This in essence requires the agency to assess the action for cumulative and long-term effects from the perspective that each generation is trustee of the environment for succeeding generations.

6. *Any irreversible and irretrievable commitments of resources* which would be involved in the proposed action should it be implemented. This requires the agency to identify the extent to which the action curtails the range of beneficial uses of the environment. It also causes the agencies to review whether it is better to use non-renewable resources or find some alternate solutions.

[10] *Environmental Quality,* Third Annual Report of the Council on Environmental Quality (USGPO August 1972) 450 pp.

7. When appropriate, a *discussion of problems and objectives* raised by other federal, state, and local agencies and by private organizations and individuals in the review process and the disposition of the issues involved. (This section may be added at the end of the review process in the final test of the environmental statement.)

Section 103 of NEPA requires all federal agencies to review their regulations and procedures, "for the purpose of determining whether there are any deficiencies or inconsistencies therein which prohibit full compliance with the purposes and provisions of this Act and shall propose to the President. . . .such measures as may be necessary to bring their authority and policies into conformity with. . this Act."

Consultation with Other Federal Agencies. A federal agency preparing an environmental impact statement should consult with and obtain comments from other federal agencies with jurisdiction by law or special expertise with respect to the environmental impacts involved. These federal agencies include components of:[11]

Advisory Council on Historic Preservation
Department of Agriculture
Department of Commerce
Department of Defense
Department of Health, Education, and Welfare
Department of Housing and Urban Development
Department of the Interior
Department of State
Department of Transportation
Atomic Energy Commission
Federal Power Commission
Environmental Protection Agency
Office of Economic Opportunity

For actions specifically affecting the environment within their geographic jurisdictions, examples of the types of federal and federal-state agencies to be consulted are:

Tennessee Valley Authority
Appalachian Regional Commission
National Capital Planning Commission
Delaware River Basin Commission
Susquehanna River Basin Commission

Agencies seeking comment should determine which of the agencies are appropriate to consult on the basis of their areas of expertise. A list of federal agencies with jurisdiction by law or qualified because of special expertise to comment on various types of environmental impacts is given on page 414 of the Third Annual Report of CEQ.[12]

Environmental Impact Assessments and Statements. For most Army actions or projects it would be necessary only to prepare an environmental impact assessment (EIA), which is basically an intraagency environmental review document. But, when the project is expected to have a significant adverse effect on the quality of the human environment or when the adverse effect on the environment is expected to be controversial, the proponent agency is required to prepare and formally file with CEQ an environmental impact statement (EIS).

To clarify the difference between an EIA and an EIS, the following definitions are presented.

Preparation of an EIA involves a formal evaluation process to determine the probable environmental impacts of the proposed action, and to determine whether the adverse impacts are significant or controversial. The resulting documentation is termed an EIA.

An EIS is a detailed, objective analysis of the environmental consequences of a proposed action which all federal government agencies are required to prepare and use in their agency review and decision-making processes before they take any major action which significantly affects the quality of the human environment or which is controversial for environmental reasons.

The format for an EIA is to be established by each agency. It is recommended that it be patterned after CEQ guidelines. For both the EIA and the EIS, all points 1 through 7 as previously outlined should be addressed. A review of the EIS by other Federal agencies and the public is required.

At the present time there is considerable federal activity in preparation of an EIS. Figures 1 and 2 are the number of EIS prepared by agency and by type of federal action as filed with CEQ through May 1972.

[11] *Environmental Quality*, Third Annual Report of the Council on Environmental Quality (USGPO August 1972) 450 pp.

[12] *Environmental Quality*.

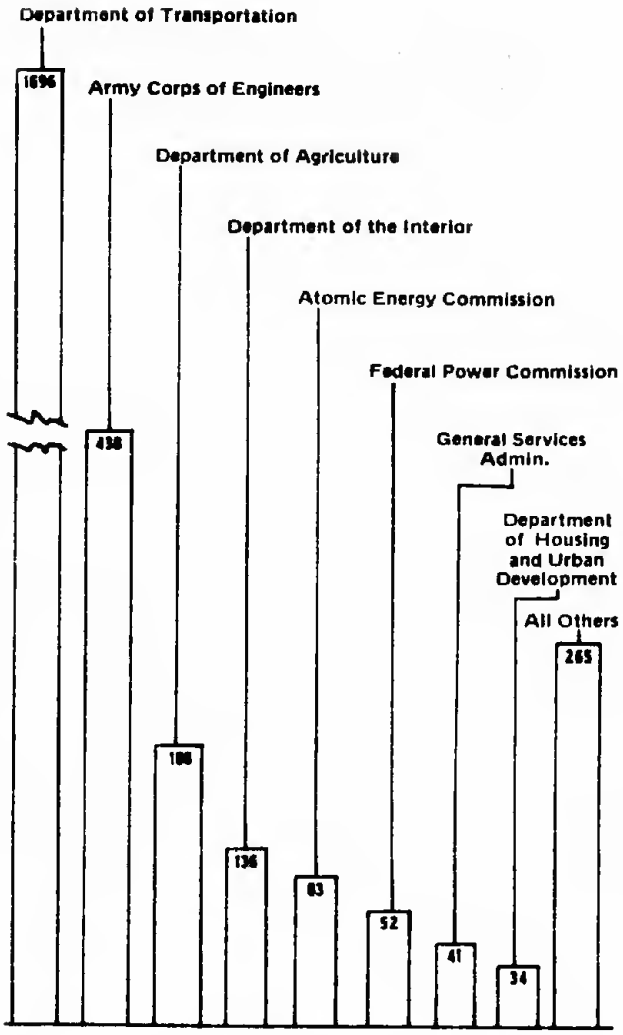


Figure 1. Number of EIS by Agencies Filed With CEQ Through May 1972

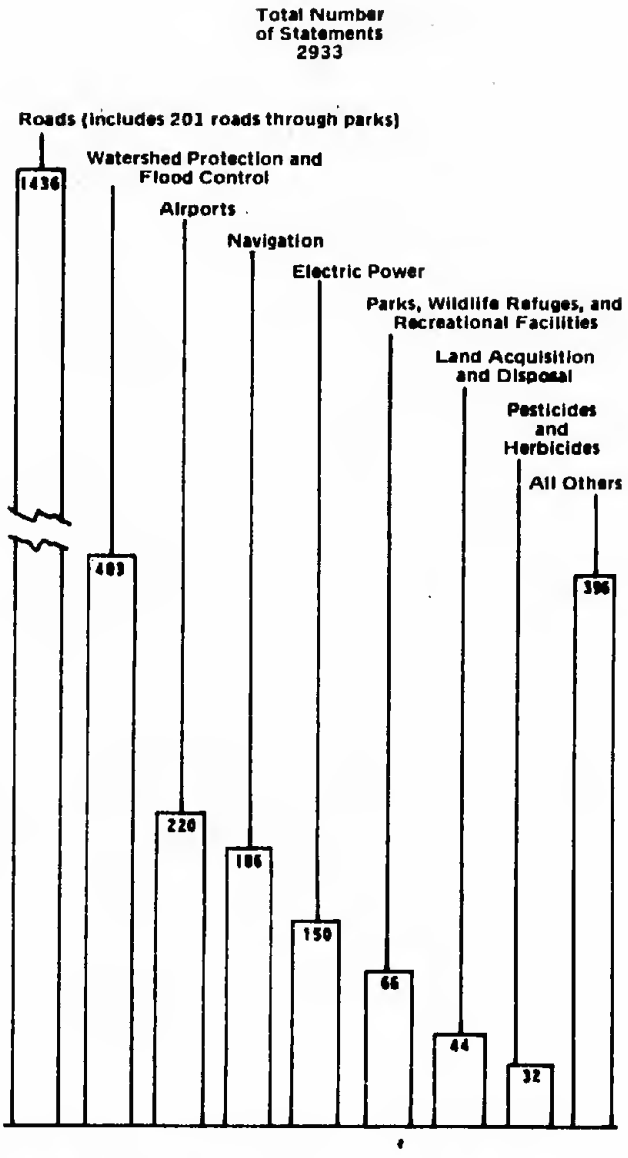


Figure 2. Number of EIS by Type of Federal Action Filed with CEQ Through May 1972

Objective. The objective of this study is to develop systematic procedures that can be used by personnel at all levels of the Army to prepare and review environmental impact assessments and statements for all Army programs. Army programs would include all Army functional areas such as construction, research and development, operation and maintenance, real estate acquisition or outleases of land, mission change of a base, procurement, training programs, administration and support, and industrial activities.

The procedures and information developed and made available to users as a result of this study would assist Army personnel in:

1. Considering the environment in decision making;

2. Minimizing adverse environmental impacts due to implementing Army programs;

3. Preparing meaningful and comprehensive EIA and EIS; and

4. Reducing the cost of preparing and reviewing EIA and EIS. Thus users would be more responsive to NEPA, Executive Order 11514 and other environmental regulations and guidelines.

2 APPROACH

Requirements of NEPA, the subsequent Executive Order, and CEQ guidelines[13] emphasize that agencies are to develop *systematic procedures* to "insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision making which may have an impact on man's environment."[14] The context of each of these documents indicates that systematic procedures in this case are those which are organized, orderly, thorough, and ever present—not those which are routine and "mechanical."

This study was initiated to enable the Army to be responsive to the indicated need for systematic procedures. The overall study was designed to develop a method for evaluating environmental impacts of Army military activities within the continental United States. Because of the quantity and diversity of Army military activities and the associated environmental effects, a significant portion of the research effort was devoted to information collection and processing. The basic approach of this research was dictated by the information problem.

There are three major areas for which information was developed. The first area was information relating to all Army activities. It was necessary to identify and categorize all Army activities. The functional area was adopted as the broad category for Army activities and research was undertaken to provide details for these functional areas. The second area for which information was collected was related to defining and categorizing the elements of the environment—environmental attributes—which might be impacted. For this area, environmental attributes were identified and categorized under broad headings called technical specialties. The third area involved data collection to establish the legal constraints on changes in the environmental parameters. To do this, states were selected and relevant environmental legislation was collected, categorized, and placed in computer storage for rapid retrieval.

These major elements of this study are brought together within the environmental impact computer system (EICS-CERL) for easy user access and rapid retrieval. Details on the three major research components and the EICS-CERL for bringing these together follow in the subsequent chapters. The generalized approach for this study is depicted by the flow chart in Figure 3.

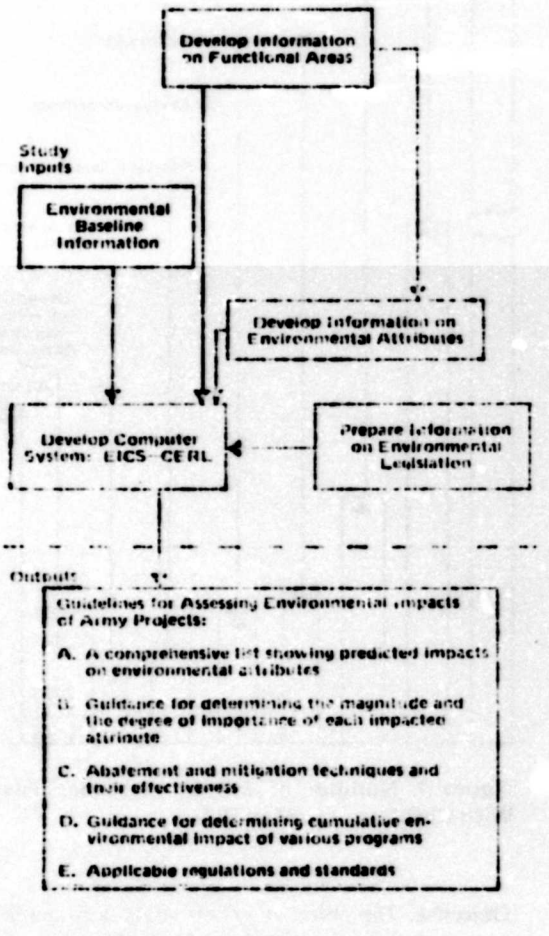


Figure 3. Generalized Study Scheme

Army Functional Areas. In developing a methodology for relating Army activities to impacted environmental attributes, it was necessary to develop a scheme for categorizing and classifying all Army activities in a systematic way. In developing a classification system consideration was given to:

1. Classification based on the Fiscal Code as documented in AR 37-100-2;

2. Classifying Army activities by installation; and

[13] *Statements on Proposed Federal Actions Affecting the Environment: Guidelines*, 36 Federal Register 7724 (Council on Environmental Quality, 1971).

[14] National Environmental Policy Act of 1969 (PL 91-190; 83 Stat 852).

3. Classification based on TAG Letter of 21 October 1971.

It was recognized that individually each of the above approaches created unique problems regarding the scope and amount of detail required. For example, by inventorying only existing installations, our system would have been inflexible and would not have been capable of incorporating potential impacts in areas other than those specifically identified in the data base. New installations would then have to be totally assessed and entered as a specific addition to the data base. Also, in order to assess impacts at a specified installation it would be necessary to review the baseline data for that specific site. Such information was not available in sufficient detail or appropriate format when the study was begun. While these data will be gathered and entered into our system as a result of work in other work units, for this interim report the data were not accessible. Hence specific installation review for development of basic activities associated with implementing Army programs (BAAP) was not possible.

Therefore, after active consultation with Army personnel and careful review of DOD and DA guidance, a classification scheme was developed which synthesized the above approaches. This scheme generated the nine Army functional areas shown below:

1. Construction projects;
2. Operation, maintenance, and repair;
3. Training—basic to large-scale maneuvers;
4. Mission changes which increase or decrease the number or type of personnel at the installation; or change the activities of people.
5. Real estate acquisition or outleases or disposal of land;
6. Procurement;
7. Industrial plants;
8. Research, development, test, and evaluation (RDT&E); and
9. Administration and support.

These functional areas are defined to encompass all Army activities. For each functional area, the BAAPs were identified. In most cases the BAAPs which were identified were at such a level of detail that it was necessary to relate them to the functional area through a hierarchy of activities. Therefore, for most functional areas, a hierarchy of Army activities was established as follows:

- Functional area
  - Program
    - Subprogram
      - Aggregate BAAPs
        - Detailed BAAPs

Due to variations in the nature of the functional areas, some of the hierarchical levels may be missing. The scientists were asked to assess the environmental impact of activities at the detailed BAAP level. However, in cases of some technical specialties it was more meaningful to relate aggregate BAAPs or subprograms to impacted environmental attributes.

For the construction functional area, those hierarchical steps are further elaborated on in Chapter 3.

Environmental Attribute Development. In examining the impact of Army activities on the environment, it is important to establish what is impacted by these activities. For present purposes the environment is described by a series of attributes. The major effort of the work discussed in this chapter was the development of this list of environmental attributes. In addition, the system for relating Army activities (BAAPs) to the environment was also designed. CERL scientists, Army personnel from staff agencies, and an interdisciplinary team of scientists from outside CERL were involved in developing this system. The relationships of these elements are shown diagrammetrically in Figure 4.

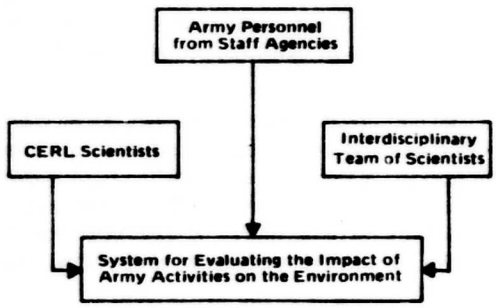


Figure 4. Elements in the Development of the Assessment System

The interdisciplinary team was composed of 16 scientists who represented the following disciplines: earth science, plant ecology, zoology, noise pollution, groundwater, sociology, surface water, land use and resource management, environmental health science, information science, regional economics,

economics, air quality, and transportation. Names and areas of specialty for all the scientists involved in this study are given in the Foreword.

A list of contact points which included Army personnel from different staff agencies was provided by Deputy Chief of Staff Installations, Environmental Office (DALO-INE). Input from these contact points, where applicable, was utilized in the study. The list of Army contact points is included in the Appendix. The contact points who actively participated in the study are in the foreword.

The interdisciplinary team of scientists assembled for this study and the scientists from CERL worked together in five interaction sessions at CERL for developing the system for relating BAAPs to the environment. The first session was held on 29 June 1972, and the last formal session was held on 28 September 1972. Altogether, 12 days were spent in the interaction sessions; the time between the interaction sessions was spent in developing BAAPs, developing the assessment system, clarifying the attribute listings, and preparing for subsequent interaction sessions.

The sessions commenced by orienting the scientists to the problem and informing them of the diversified Army activities to be assessed. They terminated with completion of the entries for the impact matrices. After the last session each scientist was requested to submit a letter report encompassing the work accomplished during the study period. These interaction sessions were central to developing interdisciplinary and systematic procedures for relating BAAPs to potential impacts on the environment.

The outputs of these sessions were detailed lists of environmental attributes, by technical specialty, information regarding which BAAPs would impact which attributes, and how BAAPs would impact these attributes. Environmental attributes for the following scientific technical specialties were developed:

1. Ecology
2. Health science
3. Air quality
4. Surface water
5. Groundwater
6. Sociology
7. Regional economics
8. Earth science
9. Land use
10. Noise
11. Transportation

Under each technical specialty area, three types of attributes are developed (Figure 5): detailed attributes, review level attributes, and controversial attributes. Review level and controversial attributes were introduced because the detailed attributes do

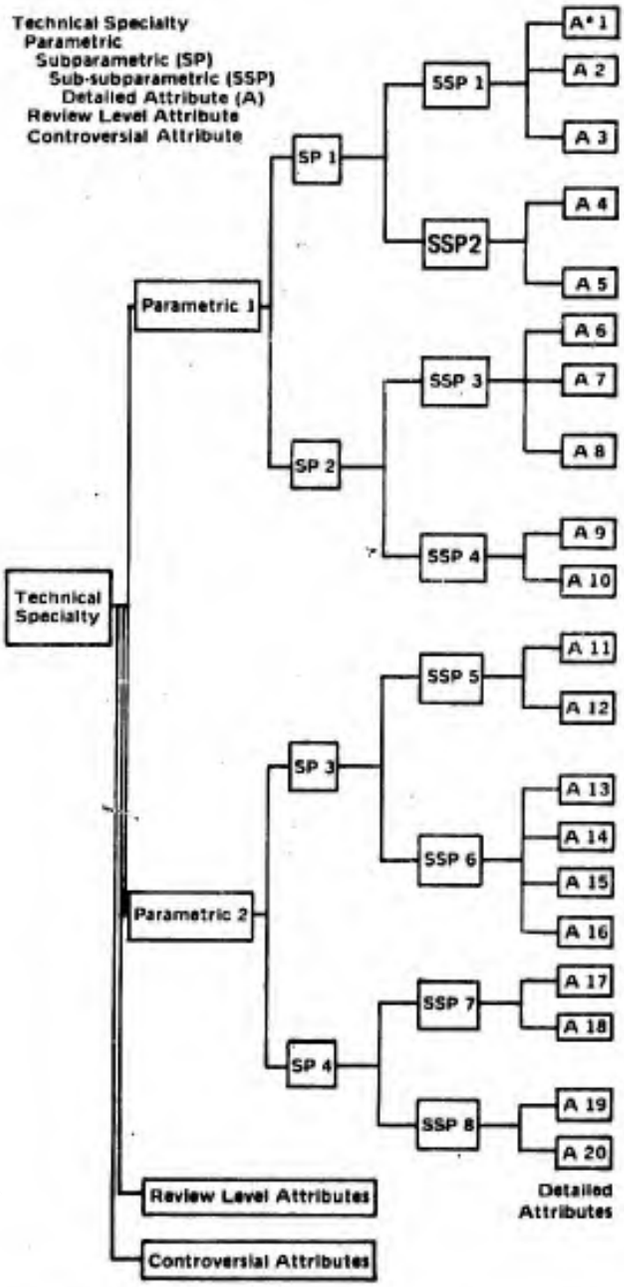


Figure 5. Sample Hierarchy Within a Technical Specialty

not provide the overview which may be necessary for some potential users of the system.

Detailed Attributes. Detailed attributes are defined as parameters which may be used to describe the condition of the environment, changes which would include changes in the environment.

A brief description of each detailed attribute was prepared by the scientists to permit a user to gain some appreciation of the nature of a potential environmental impact. To promote consistency among all members of the scientific team and to maximize convenience in using the descriptions, a standard format was used in preparing descriptions of detailed environmental attributes. Each description is made up of sections, A-D, which contain the following information:

A. Definition of the attribute;

B. Information on how the attributes might be affected or influenced by Army actions;

C. Information on the source of the effect or the pollutant; and

D. Information on how the effect on the environmental attribute might affect other biophysical and socio-economic attributes, i.e., interaction with other environmental attributes. In addition, any quanitative information regarding the attribute and information regarding standards and regulations was to be included in this section.

Examples of typical information provided for detailed attributes are given in Chapter 4. Information on detailed attributes would be available from CERL on request to a user who wishes to know more about attributes which may be impacted.

Review Level Attributes. Review level attributes are intended to present an overview of the nature of potential impacts without the detail provided by the detailed attributes. As such they are useful for summarizing the potential environmental impact by personnel at the management or general staff level. A brief and general description of each review level attribute was developed and this information is also available on request from CERL.

These attributes were developed to insure effects on the environment would be couched in relatively familiar (to the layman) terminology. Thus they do not represent a straightforward aggregation of detailed attributes.

Controversial Attributes. Intense public concern for maintenance of environmental quality, confusion as to the effects of environmental impacts, the necessity for establishing tradeoffs between economic gain or mission accomplishments and environmental insult, and other factors may contribute to controversy regarding Army activities. Inasmuch as NEPA specifically requires that potentially controversial effects be considered in assessing environmental impact, identification has been made of those environmental attributes which are considered particularly prone to such reaction. Although the labeling of specific attributes as controversial suggests some emotional influences, it does not necessarily imply that the public's concern is ill-founded. Further, in many cases, inadequacy of current technology justifies fear of the unknown.

The interdisiciplinary team of scientists was instructed to list and discuss those attributes which, when impacted by an Army activity, would produce a controversial reaction among the civilian population. This population was defined to include (1) local residents near the Army activity and (2) interested persons or special interest groups from anywhere within the country. Responses by these persons or groups might well differ greatly in magnitude and/or persistence.

In considering possible controversial attributes from the physical environment, it was concluded that for many attributes concerning pollutants, for example, the attributes themselves might not be controversial but controversy might arise from:

1. The alleged effects attributed to them at normal ambient concentrations;

2. The cost of abating the pollutant given the degree of uncertainty of the effect;

3. The decision as to what constitutes available technology for control; and

4. The time span necessary for legal compliance.

When Army activities, programs, or policies affect attributes of the socio-economic environment, controversy is likely to develop. Economic attributes such as those involving either basic philosophic questions dealing with political expediency and economy, or related to questions of economic efficiency and to equity, are among those which could be identified as potentially controversial.

Regardless of the technical specialty involved, different groups perceive the attributes differently and controversy arises when responsible differences of opinion exist concerning the solution of environmental problems.

Given the preceding guidance, controversial attributes were developed and for each a brief general description was prepared. Additional information on controversial and review level attributes for the different technical specialties is presented in Chapter 4 of this report.

System for Assessing Environmental Impacts. To date, considerable comprehensive research has been performed for the purpose of developing a systematic method for environmental impact assessment.[15,16,17] Most of these efforts have resulted in either complex algorithms or compound matrix approaches. They have been aimed toward the simplification of the multitude of actions--reactions and interactions that are inherent in environmental research. The matrix approach has been found to be efficient for describing the complex relationships between environmental attributes and human actions which impact those attributes. This study employs a matrix methodology in a scale much larger than reported in previous studies.

The CERL matrix provides for the prediction of nearly two million potential impacts between combinations of BAAPs and environmental attributes. In addition, a relative scale of impact, identified hereafter as a "need-to-consider scale," is provided, along with ramification remarks regarding the impacts and mitigation procedures for identifying adverse impacts. Finally, relevant federal environmental laws and regulations, and selected state environmental laws and regulations are provided. Each of these points will be elaborated on in the following sections.

Environmental Laws and Regulations. There is no central source of information regarding the relevant federal, state, and local laws, codes, and regulations for environmental protection as they relate to specific types of U.S. Army activities at particular geographic locations.

To provide this central source, geared to the Army's needs, a computerized environmental legislative data system (CELDS) is presently being developed. For this system, information is being collected and organized to permit users of the system to obtain environmental legislative data relevant to their particular decision process. Shown in Figure 6 is the overall research plan for CELDS. A draft report covering federal and six state laws (California, Illinois, New York, Virginia, Tennessee, and Kentucky) is being prepared at this time.

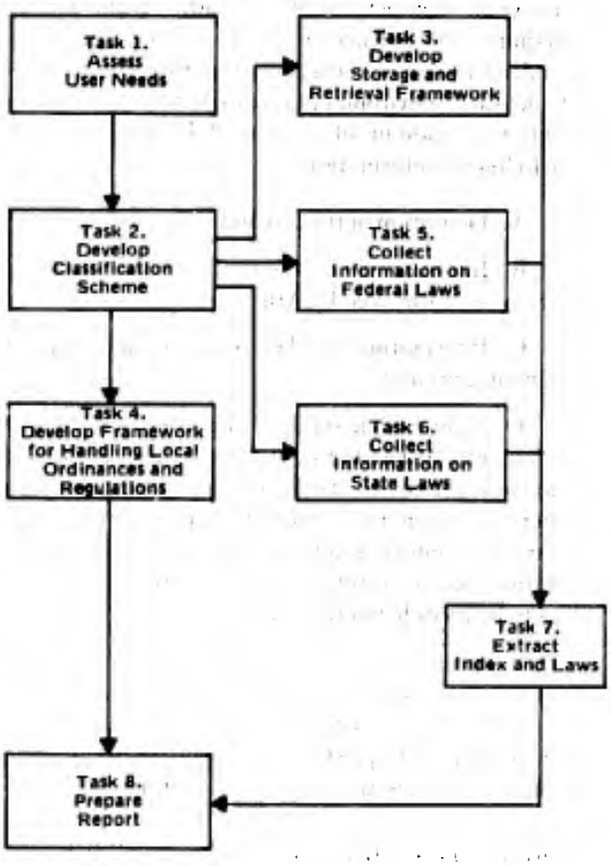


Figure 6. Research Plan For CELDS

Environmental Baseline. In relating Army activities to potential environmental impacts it is necessary to establish the environmental baseline at the location where the project or the activity is being implemented. In addition to the environmental baseline, information regarding the magnitude of the project, the temporal information, and interaction of this project with other projects in the region is necessary.

At the time of the preparation of this report, the research effort for including baseline information in

[15] *Preparation and Coordination of Environmental Statements*, ER 1105-2-507 (Department of the Army, Office of the Chief of Engineers, 1973).

[16] L.B. Leopold, F.E. Clarke, B.B. Hanshaw and J.R. Balsey, *A Procedure for Evaluating Environmental Impact*, United States Geological Survey (USGS) Circular 645 (USGS, 1971).

[17] Lloyd V. Stover, *Environmental Impact Assessment: A Procedure* (Sanders and Thomas, Inc., 1972).

relating Army activities to potential environmental impacts was not available. Since the baseline information is necessary for making a meaningful and site-specific environmental impact analysis, the scientists were asked to include comments in the ramification and qualification column such that these comments could be used by the user of the system in determining whether the potential environmental impacts shown in the matrix are applicable to his particular site. In addition, the user, by reading the descriptor package for the environmental attributes, can determine whether and how Army activities might impact this particular environmental attribute.

In the upcoming years the system will be refined such that the baseline information could be used as an input condition and the system will sort out the potential site-specific impacts for the given input condition. Also after identification of potential impacts appropriate casual relationships will be identified to define, quantatively or qualitatively, the specific major impacts.

Environmental Impact Computer System (EICS-CERL). The information developed as a result of this study is voluminous and there are many decision points associated with utilizing the system. There are approximately 800 detailed-level attributes identified in this study. For a given subprogram of a functional area the typical list of BAAPs is likely to be 100 or more. This would give nearly 80,000 possible impact interactions for each small subprogram.

Shown in Figure 7 is the general form for the environmental impact matrix used in EICS. Figure 8 shows the detail found within each technical specialty area. These matrices are included to illustrate the relationships between Army activities and environmental impacts and their format. Also shown in Figure 8 is the need-to-consider scale as indicated A, B, C, for indicating the probability of occurrence of an environmental impact. This scale will be discussed in the following section.

Need-to-Consider for Indicating Probability of Environmental Impact. For any particular BAAP there may be some impact on virtually all the environmental attributes. This does not help the person who is assessing environmental impact because the relative importance of the attributes in describing impact is not identified. A method for indicating which attributes are most likely to be impacted and

Environmental Attributes / Basic Army Activities	Ecology	Health Science	Air Quality	Surface Water	Groundwater	Sociology	Regional Economics	Earth Science	Land Use	Noise	Transportation	Other Information
Construction												
Operation, Maintenance Repair												
Training												
Mission Change												
Real Estate												
Procurement												
Industrial												
Research, Development, Test & Evaluation												
Administration												

Figure 7. Environmental Impact Matrix — General Form

which ones are likely to be the most adequate indicators of impact was developed. This involved the development and application of a *need-to-consider scale.* In addition, "a modified Delphi technique" was used to compare the relative importance of attributes grouped by technical specialties.

BAAP's	Alternate Methods of Accomplishing the Activity	Technical Specialty Water Quality					Ramifications	Mitigation Techniques
		Turbidity	Gross Solids	Floating Solids	DO	--Attributes		
Channel Excavation	Drag line, front end loader, back-hoe, dozer, hand	A*	B	C	A			

*A, B, and C are need-to-consider scales

Figure 8. Typical Impact Matrix For a Technical Specialty

Need-to-Consider Scale. Each scientist responsible for a technical specialty area was requested to assign an indicator of the need-to-consider with each of the environmental attributes for every BAAP. For each BAAP scientist considered which of the attributes in his technical specialty should be considered in assessing the impact of that BAAP.

The scale that was used is as follows:

A = definitely consider this factor as being potentially impacted by the BAAP

B = possible effect, requires consideration

C = consider in special cases

$\pm$ = for beneficial or detrimental socio-economic effects

Blank = as far as we know, without knowing all the details of your project, you need not consider this attribute; please check the ramification column.

Different technical specialty areas and attributes within an area may not always be considered to be equally important in explaining the impact of different Army projects on the environment. It was therefore necessary to develop a modified Delphi technique for weighing the different technical specialties according to their relative importance; and also for weighing the relative importance of detailed attributes within a technical specialty. To do the first part, the group of experts in the technical specialty areas was seated in a room and given the opportunity to provide their own assessment of the relative importance of each of the areas for indicating degree of environmental impact.

The weighing procedure was accomplished in a very simple manner. A deck of 11 cards was given to each person participating in the weighing. Each card had a different technical specialty named on it. Each of the participants was then requested to rank the technical specialties according to their relative importance in explaining changes in the environment from Army activities. Then the individual was asked to go back through the list making a pairwise comparison between technical specialties, beginning with the most important one first. The most important technical specialty was compared with the next most important by each individual, and the second technical specialty was assigned a percentage which was to reflect the percentage of importance of the second with respect to the first. For example, the first technical area would receive a weight of 100 percent, and the second most important technical area may have been considered by the specialist to be only, say, 90 percent as important as the first technical specialty. Then the second and the third most important technical specialties were compared, and the third most important area was assigned a number, for example, 95 percent as its relative importance compared to the second most important technical specialty. A sample diagram of the comparison is presented in Figure 9.

The formula for weighing the technical specialties is:

$$W_{ij} = \frac{V_{ij}}{\sum_{i-1}^{n} V_{ij}} p \qquad (i = 1,2,3,\ldots,n)$$

$$V_{ij} = \begin{cases} 1 & (i = 1) \\ V_{i-1\,j} X_{ij} & (i = 2,3,\ldots,n) \end{cases}$$

where

W_{ij} = weight for the i^{th} technical specialty area by the jth scientist;

n = number of technical specialties;

P = 1000—total number of points to be distributed among the technical specialites;

X_{ij} = the j^{th} scientist's assessment of the ratio of importance of the i^{th} technical specialty in relation to the $(i-1)^{th}$ technical specialty;

V_{ij} = measure of relative weight for the i^{th} technical specialty area by the j^{th} scientist.

To do the second part, i.e., to rank attributes within a technical specialty, each scientist worked independently in ranking attributes in his own specialty.

The information from this pairwise comparison was then used to calculate the relative importance of each of these technical specialty areas, and a total of 1000 points was distributed among the technical specialties according to their relative importance.

After the weights were calculated from one round of this procedure, the information on the relative weights was presented again to the experts, a discussion of the weights was undertaken, and a second round of pairwise comparisons was made.

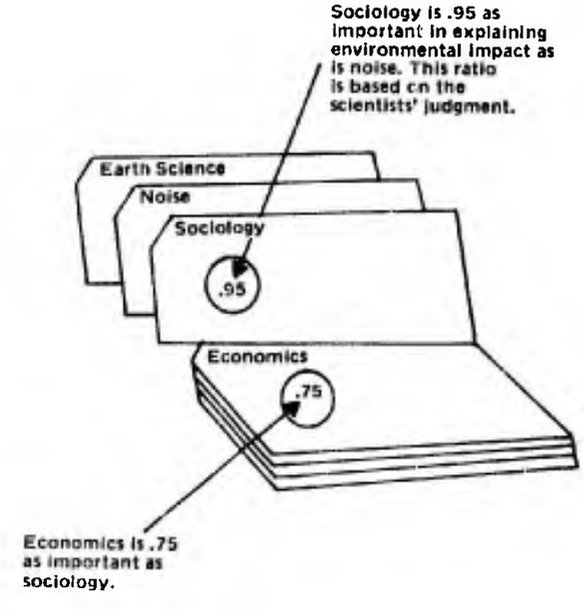


Figure 9. Pairwise Comparison of Environmental Attributes

The Delphi technique is a procedure developed at the Rand Corporation for eliciting and processing the opinions of a group of experts knowledgeable in the various areas involved. A systematic and controlled process of queuing and aggregating the judgments of members of a group is used, stress is placed upon iteration with feedback to arrive at a convergent consensus. The weighing system discussed in the preceding section does not include all the elements of a Delphi technique. In addition, results of these ranking sessions need further study, feedback and substantive input from field data before implementation in the EICS.

Use of EICS. Since the user is interested only in the major impacted attributes and information relevant to his project, a comprehensive environmental impact computer system (EICS) was developed to permit screening of the attributes.* In addition to providing the user with only the information relevant to his project, the system has the flexibility of being operated in an interactive mode which allows the user to utilize the system for decision-making purposes both at the operating and the general staff levels. Requirements for utilizing the system are discussed in the following section.

User Input Requirement. The system can be accessed by either an interactive terminal or by utilizing batch process. Figure 10 shows the different options available in the computer system. General input for the system includes the following items:

1. Title of project
2. Number of functional areas
3. Environmental impact level
   - Review level
   - Detail
   - Controversial
4. Impact scale
   - A = definitely consider
   - B = possible effect, requires consideration
   - C = consider in special cases
5. Number of programs (how many?)
6. Program code (which one?)
7. List of all BAAPs for the functional area
8. Choice of technical specialties
9. Number of subprograms (how many?)

*Details of the system will be presented in the CERL report entitled *Environmental Impact Computer System;* included in this report are a flow chart for the EICS, a User Manual, a typical computer output from the system, and a description of the development of the system.

10. Subprogram code (which one?)
11. List of BAAPs for the subprograms
12. Given the lower and upper BAAP codes, list the alternative methods of accomplishment
13. List all the programs and subprograms that have environmental impact data loaded in the system
14. Descriptive text for the detail attribute
    Definition
    How affected
    Source
    Interaction

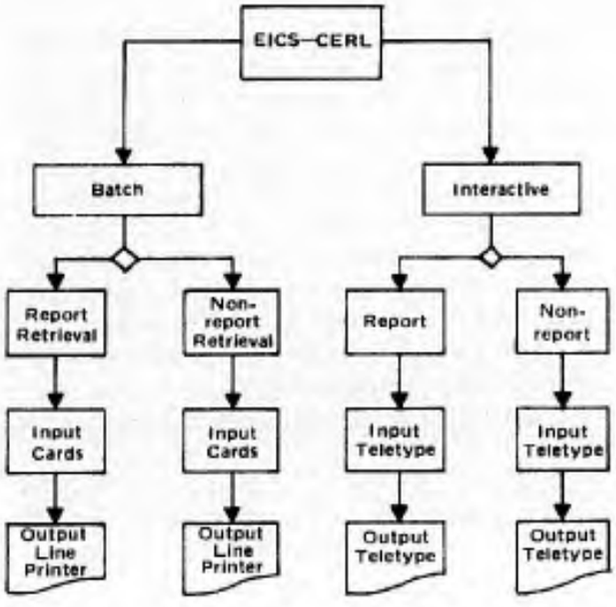


Figure 10. Flow Chart Showing Different Options Availabel in EICS

Further refinement and versatility will be implemented in the input system during the course of the study. In the future, it is planned that input items would include:

1. Dollar cost of the project;*
2. Geographic location;
3. Time frame for implementation;
4. Season code;
5. Environmental baseline information;
6. Information on baseline profile.

*The cost of the project may be important in determining the socio-economic impacts. For instance, federal expenditure in a depressed region may alleviate some of the unemployment and other social problems associated with unemployment.

The purpose of this input information would, of course, be to allow the EICS to further refine the output information taking into account the input provided.

Output from EICS. The EICS will provide the user with the following information on an interactive basis:

1. A comprehensive list showing attributes most likely to be impacted;
2. Information on the importance of considering the identified attributes;
3. Information on where or why controversy may arise;
4. Information on constraining laws, regulations, and ordinances.
5. Relevant information on ramification remarks and mitigation techniques and their effectiveness.

As the first four points have been discussed previously only the last point will be elaborated on here; and

Ramification Remarks and Mitigation Procedures. Due to the complex nature of the impacts and interactions associated with Army programs, it was frequently necessary for the scientists to qualify their matrix scores with ramification or qualification statements. These statements typically took the form of caveats regarding differing degrees of impact depending upon time of year, site condition, climate, and magnitude of activity.

Examples of ramification remarks are included in Chapter 4.

In evaluating the potential effects of BAAPs on environmental attributes, an attempt was made to indicate possible measures for minimizing or avoiding significant impacts and, where possible, effectiveness of these measures. It is important to point out that identification of proper abatement procedures is highly dependent on local conditions and critical evaluation of the problem by an expert is needed.

Abatement and mitigation techniques identified as a result of this study give some idea of the general nature of the types of controls which might be exercised. Also, the mitigation procedures presented may serve to illustrate the nature of the potential impact and to demonstrate the reason a particular BAAP is of concern from the standpoint of environmental impact.

Examples of abatement and mitigation techniques are included in Chapter 4.

3 FUNCTIONAL AREAS

As discussed earlier in Chapter 2, this chapter is devoted to an in-depth discussion of the nine Army functional areas. For review purposes these functional areas are repeated here:

1. Construction;
2. Operation, maintenance, and repair (OM&R);
3. Training;
4. Mission change;
5. Real estate;
6. Procurement;
7. Industrial;
8. Research, development, test, and evaluation (RDT&E);
9. Administration.

The reasons for utilizing these functional areas for categorizing and classifying all Army activities were discussed in Chapter 2.

To date only the construction functional area has been studied in detail and an operating system for this functional area is now complete. The system will be field tested and further refined. Other functional areas will be studied in turn.

Functional Area — Construction.

Relevant References.

1. AR 415-2 Department of Defense construction criteria.
2. AR 415-13 MCA program—disposal of structures.
3. AR 415-28 Department of the Army facility classes and construction categories.
4. AR 415-35 Minor construction.
5. ER 415-2-1 Policies and practices—clearing.
6. ER 415-2-301 Construction policies and practices.
7. EM 1110 SERIES Engineering and design.
8. TM 5-258 Pile construction.
9. TM 5-312 Military fixed bridges.
10. TM 5-331 SERIES Utilization of engineer construction equipment.
11. TM 5-332 Pits and quarries.
12. TM 5-337 Paving and surfacing operations.
13. TM 5-342 Logging and sawmill operation.
14. TM 5-360 Port construction and rehabilitation.
15. TM 5-370 Railroad construction.
16. TM 5-551B Carpentry.
17. TM 5-805-1 Standard practice for concrete for military construction.
18. TM 5-805-4 Noise control for mechanical equipment.
19. TM 5-809-3 Structural design: masonry construction for buildings.
20. TM 5-814-5 Sanitary engineering: sanitary fill.
21. TM 5-850-1 Transportation facilities, military ports.
22. TM 5-857-1 Engineering and design: design of underground installations in rock, general planning considerations.

Commentary. In the light of increasing general environmental awareness and concern, man's activities are requiring increasingly closer scrutiny regarding consideration of potential environmental impact. Due largely to their highly visible nature, construction projects and construction-related activities maintain a high priority in the realm of environmental impact assessment.

For CONUS alone, combined major and minor Army military construction operations and related activities approach an annual expenditure of one billion dollars. Thus the military construction program places the Army in a position of respon bility for the utilization of vast amounts of n power, materials, and equipment. In the proces accomplishing construction objectives, there exists the potential to affect the socio-economic as well as the biophysical environment. Although the environmental effects may vary in severity and duration, they nonetheless must be carefully and systematically evaluated.

Environmental impact assessment of construction projects, as in the case of all other Army activities, should begin in the planning stages of the project. Consideration should be given to the life cycle of the project or the activity. Obviously, there would be alternatives for both the overall project and for the detail design aspects within a project. These alternatives should be addressed in the environmental impact analysis.

The BAAPs were developed corresponding to the sequence of activities normally followed in construction operations. The following are the aggregate BAAPs:

1. Site preparation;
2. Demolition;
3. Removal and disposal;

4. Excavation;
5. Earthworks and borrowing;
6. Quarrying and stonework;
7. Subsurface excavation;
8. Foundation;
9. Bituminous construction;
10. Concrete construction;
11. Masonry construction;
12. Steel construction;
13. Lumber construction; and
14. Finishing.

These aggregate BAAPs were broken down further into detailed BAAPs, or basic activities. Finally, alternate means, equipment, and techniques utilized to achieve construction objectives were listed along with the detailed BAAPs.

Preliminary works (e.g., site access, batching plants, utilities, etc.) were not included in the construction BAAP list but are to be considered in the following manner:

1. Existing—treat the assessment of preliminary works as a normal OM&R function; or

2. Build new—treat the assessment of preliminary work as a separate new construction project.

Due to the many variations in types of construction projects, it became apparent that not all the detailed BAAPs in the comprehensive list would be applicable to each project. The following steps were taken to reduce needless duplication.

1. AR 418-28 was consulted to determine Army facility classes and construction categories;

2. Category groups within each facility class were identified; and

3. The comprehensive construction BAAP list was reduced and tailored to represent activities most likely to be performed for a particular category group within the facility classes.

As a result of this operation, the user of the system need only specify the facility class and category group in order to access the activities associated with the construction of that particular project. See the User Manual in the Appendix for further details concerning the facility class and category groups available in the system.

Examples of Typical BAAPs.

BAAP NO	BAAP NAME	METHODS OF ACCOMPLISHMENT
73	CLEARING	CHAIN SAW FRONT-END LOADER
74	GRUBBING	DOZER GRADER FRONT-END LOADER HAND
75	STUMPING	DOZER RIPPER SHOVEL BACKHOE FRONT-END LOADER EXPLOSIVES HAND
80	DEMOLITION	
81	CONCRETE	PNEUMATIC TOOLS IMPACT TOOLS HYDRAULIC TOOLS EXPLOSIVES
82	STEEL	BULLDOZER EXPLOSIVES CUTTING STEEL BALL
83	LUMBER	DISMANTLING INCINERATION BULLDOZER
84	BRICK	PNEUMATIC TOOLS IMPACT TOOLS HYDRAULIC TOOLS EXPLOSIVES

Functional Area — Operation, Maintenance, and Repair.

Relevant References.

1. AR 37-100-72 The Army management structure (fiscal code) — appropriations and funds available for obligation expense and expenditure
2. AR 210-50 Family housing management
3. AR 420-13 Organization, functions, and utilization of personnel
4. AR 420-70 Building and structures
5. AR 420-72 Surfaced areas
6. PAM 420-5 Work performance standards for post engineering
7. PAM 420-6 The work management system
8. TM 5-609 thru 5-696 Maintenance, repair, and operation

Commentary. Under this functional area there are two major programs: repair, and operation and maintanance.

Repair activities are characterized by removal of defective parts and equipment and the reinstallation of a functional item. This item may be

either a rehabilitated, used assembly or an entirely new part. In all cases, repair of buildings generally involves replacement of worn or broken areas rather than construction of entirely new structures.

Activities associated with operation and maintenance are similar to activities associated with running a small city. The BAAPs are grouped into categories descriptive of their activities (which make them unique) and related to the Army accounting system (to make them more accessible).

Examples of Typical BAAPs.

REPAIR
  REPAIR OF BUILDINGS
    WOODWORKING
      REPLACE DOORS, WINDOWS
      SCREENING, WIRE, INSECT
      REPLACE WOOD TRIM
      REMOVE OLD FLOORING, SUBFLOOR, INSTALL NEW MATERIALS (WOOD, LINOLEUM, ASHPHALT TILES)
      VARNISH, ASPHALT
      VARNISH, SPAR PHENOLIC—RESIN
      WOOD PRESERVATIVE, TREATING PRACTICES
      INSTALL ACOUSTIC TILE
      INSTALL PLYWOOD CEILINGS, WALLS
      INSTALL GYPSUM BOARD OR MASONITE
      INSTALL ABESTOS-CEMENT SHINGLES
      REPLACE WOOD ROOF DECK
      ROOFING
OPERATION AND MAINTENANCE
  BASE OPERATIONS
    OPERATION AND MAINTENANCE OF AIRCRAFT
      WASH DOWN THE AIRCRAFT
      LUBRICATION OF AIRCRAFT AND ATTACHMENTS
      REFUELING OF THE AIRCRAFT
      FLYING OPERATIONS
    O&M OF AUTOMOTIVE EQUIPMENT
      WASH DOWN THE VEHICLES
      LUBRICATION (OIL CHANGES)
      REFUELING
      DRIVING
      TUNING
    O&M OF COMBAT VEHICLES AND CONSTRUCTION EQUIPMENT
      WASH
      LUBRICATE
      REFUEL
      TUNE
      OPERATE

Functional Area — Training.

Relevant References.

1. AR 11-21 Environmental pollution abatement.
2. AR 37-100-72 The Army management structure (fiscal code)—Appropriation and funds available for obligation expense and expenditure.
3. AR 40-4 Army medical department facilities.
4. AR 71-1 Army combat developments.
5. AR 190-37 Disciplinary barracks.
6. AR 350-1 Army training.
7. AR 351-1 Military education and training.
8. AR 601-136 Training programs for Army medical specialist corps officer procurement.
9. AR 611-201 Enlisted military occupational specialties.
10. CON REG 350-1 ANNEX Series Army training.
11. CON SUPPLEMENT 1 to AR 350-1 Army training.
12. DA PAMPHLET NO.310-7 U.S. Army equipment index of modification work orders.

Commentary. For training activities three programs have been identified: (1) support activities, (2) academic training, and (3) practical training.

Support activities include those activities associated withsthe quartering, feeding, and movement of individuals during periods of training. The scale of support is dependent upon the number of personnel involved.

Academic training is essentially classroom instruction, and is carried out in conjunction with the practical training program. The practical training program for an individual progresses from basic combat training (BCT) to advanced individual training (AIT) and finally to unit training or specialty school. There are three levels of unit training: basic unit training (BUT); advanced unit training (AUT); and operational readiness training (ORT).

BCT classes are generally at a battalion level, i.e., approximately 600 individuals enter a given training phase together. Classroom instruction will be limited to either 40 or 200 men depending on the detail of instruction.

AIT classes follow BCT sizes and phasing; however, the subject matter is much more limited in scope and proficiency is the main goal.

BUT is conducted at the company level with approximately 200 men. The unit will cycle through the training phases to develop teamwork proficiency as well as individual proficiency.

AUT is conducted at the battalion level (600 to 1000 men). More complex operations are practiced, but individual proficiency is not tested in the area of weapons firing.

During ORT, field exercises are conducted at strengths up to the division level (approximately 15,000 men). Some complex operations may involve more than one division and interservice participation. Since many of the large-scale field exercises are conducted outside the military installations, they are more visible to the public. Consequently, the ORT exercises are most likely to cause controversy.

Examples of Typical BAAPs.

PRACTICAL TRAINING PROGRAM
- WEAPONS TRAINING
  - FIRING SMALL ARMS
    - INDIVIDUAL WEAPON, RAPID OR AUTOMATIC FIRE (RIFLE, PISTOL).
    - INDIVIDUAL WEAPON, RAPID OR AUTOMATIC FIRE (RIFLE, PISTOL)
    - CREW WEAPON, SINGLE FIRE (ROCKET LAUNCHER)
    - CREW WEAPON, RAPID OR AUTOMATIC FIRE (MACHINE GUN)
    - FIRING GRENADE LAUNCHER
  - FIRING ARTILLERY (CREW WEAPONS)
    - FLAT TRAJECTORY (TANK RIFLE)
    - HIGH ARC TRAJECTORY (MORTARS, HOWITZERS)
  - FIRING MISSILES (CREW WEAPONS)
    - SURFACE TO SURFACE
    - SURFACE TO AIR
  - USING EXPLOSIVES
    - ANTIPERSONNEL MINES
    - ANTITANK MINES
    - DEMOLITION
    - DISPOSAL OF FAULTY ORDINANCE
    - HAND GRENADES, BOMBS, ETC.
  - OTHER WEAPONS
    - BAYONET DRILL AND OBSTACLE COURSE
    - FIRING FLAME THROWERS
    - USE OF BARBED WIRE
    - USE OF CHEMICAL WARFARE
    - USE OF RADIATION WARFARE

Functional Area — Mission Change.

Relevant References.

1. AR 210-15 Activation, inactivation, or change in status of installations
2. AR 210-17 Inactivation of installation
3. ER 1-1-6 Transfer of missions and functions providing and obtaining support services
4. ER 614-1-1 Assignments (of personnel)

Commentary. Mission statements for elements of the Army are essentially scopes of work. The affected Army elements may be major commands such as Continental Army Command and Army Materiel Command, Military Traffic Management and Terminal Service, etc., or they may be smaller commands or installations such as Fort Hood, Texas, Fort Belvoir, Virginia, and Fort Rucker, Alabama. The mission statement says what, where, sometimes when, how, and by whom particular objectives are to be accomplished. Activities are carried out to satisfy the requirements of the mission statement under each of the other functional areas previously discussed. Assessment of the impact of these activities is the responsibility of the commanding officer. However, changes in the mission will alter the impact of the activities. The changes are imposed from higher to lower headquarters by policy decision. As a consequence of mission changes on a base (to include tenants on the base) certain activities take place with respect to that change. Some activities unique to mission change are discussed here.

Examples of Typical BAAPs.

DECREASE IN PERSONNEL STRENGTH
INCREASE IN PERSONNEL STRENGTH
DECREASE OF GRADE STRUCTURE OR RANK
INCREASE OF GRADE STRUCTURE OR RANK
ALTERATION OF JOB
ALTERATION OF JOB QUALIFICATION
ALTERATION OF CONSTRAINT (AGE, SEX, HEALTH)
ADDITION OF A FUNCTION OR TASK
REDUCTION OR DELETION OF A FUNCTION OR TASK

There are policy and political implications in the BAAPs for mission change. Further discussion and qualifiers are presented.

Discussion. Changes in personnel strength are often directed from higher headquarters. In general, a directive will come down which stipulates that a certain percentage of the existing work force must be reduced (or approval is granted by higher headquarters to a request for an increase in work force). In the case of reduction, the alternatives are to allow a strength to slip by attrition through retirement and resignation or to lay off the individuals to achieve the necessary strength. Usually it is up to the individual command to make a decision on the mode of reduction of troop strength, civilian strength, or a combination thereof. Reductions (or increases) in grade structure are again usually directed by higher levels and may be met by filling the remaining job slots with lower grade personnel, reducing the grades of existing personnel or removal of existing personnel by transfer, resignation, attrition, or lay-off.

Alteration of a job type is usually a consequence of addition or deletion of a function. This results in a

different kind of individual required to complete the mission. Alteration of the job qualification is generally by specification. Alteration of the physical constraints is again generally by specification in that the requirements for specific health, age, or sex limits to perform a certain job are changed.

An example of a change is a recent requirement of the Civil Service Board that the GS grade for sewage treatment plant operators be reduced from GS-7 to GS-5. The consequence of this was (1) change in grade structure, (2) alteration of the job qualification, and (3) a general reduction in personnel strength because people were overqualified and had to be removed from these positions.

The addition or deletion of a function is always by specification. The increase or decrease of quantity of production, whether it be trained troops or materials or some other thing, is always by specification. The following are some examples of additions and deletions of functions: addition of an air calvary division at Fort Hood; the addition of the requirement to perform on site metal plating at Red River (Texas) Army Depot; the deletion of military intelligence training at Fort Holabird, Maryland; reactivation of the 9th Infantry division at Fort Lewis, Washington; and the deletion of biological warfare research at Fort Dietrich, Maryland. The following are some examples of changes in quantity of production: the increase in required number of trained paratroopers from Fort Benning, Georgia; the decrease in number of trained physicians from Fort Sam Houston, Texas; an increase in the number of trained helicopter pilots from Fort Rucker; and an increase in the amount of TNT produced at Radford Army Ammunition Plant.

The following are qualifiers:

1. The location of the activity.
2. The regional influence of the activity.

The location of an activity or a regional sphere of influence of an activity is designated by higher headquarters. Examples of change of location of activity are: transfer of the 82nd Airborne Division from Fort Benning, Georgia, to Fort Bragg, North Carolina; transfer of the training function of military intelligence from Fort Holabird, Maryland, to Fort Huachuca, Arizona; and transfer of the paint and corrosion technology laboratory from Rock Island, (Ill.) Arsenal to Picatinney, (N.Y.) Arsenal. An example of a change of regional influence of an activity is the consolidation o the Fourth and Fifth Army Medical Laboratories at Fort Sam Houston, Texas, to cover all of the territory initially covered separately by these laboratories.

3. The rapidity with which BAAPs are implemented.
4. The duration of change.
5. The frequency of change.

The rapidity with which these actions might take place range from a period of a few months for small activities to periods over a year or more for the closing of an installation. The duration of a change may be permanent such as the closing of an installation or short term such as increases or decreases in production or manpower strength. The frequency of change is often dictated by outside influences such as political climate.

Functional Area — Real Estate.

Relevant References.

1. AR 405-80 Granting use of real estate
2. AR 405-10 Acquisition of real property and interests therein
3. AR 405-90 Disposal of real estate
4. ER 405-1-200 thru 405-1-1000 Land acquisition and disposition
5. ER 405-2-150 thru 405-2-1061 Land management and planning

Commentary. Most of the BAAPs associated with the real estate functional area should be thought of as policy BAAPs. That is to say, policy BAAPs are intangible actions such as a decision to buy land, while an activity BAAP would be clearing brush or maneuvering a vehicle in the field. In some cases, policy BAAPs can result in substantially more widespread environmental impacts than activity BAAPs. For example, a decision to reduce Army nationwide expenditures by 30 percent would result in substantial economic disruptions across the nation. On the other hand, clearing the brush from a construction site might have only local watershed implications.

Real estate BAAPs are divided into three areas: (1) real estate acquisition, (2) real estate dispositions, and (3) outleases of land and sale of products from Army-owned land.

Examples of Typical BAAPs.

REAL ESTATE ACQUISITION
ACQUISITION BY PURCHASE

ACQUISITION BY CONDEMNATION
REAL ESTATE DISPOSITIONS
DISPOSITION TO GOVERNMENTAL AGENCIES
DISPOSITION TO THE PUBLIC
OUTLEASES OF LAND
OUTLEASING FOR GRAZING
OUTLEASING FOR CROPS
OUTLEASING FOR MINERAL EXTRACTION

To assess the environmental impact due to implementation of the aforementioned BAAPs, it is necessary to describe the policy actions in further detail. As an example, a discussion of real estate acquisition by purchase and condemnation follows.

Real Estate Acquisitions. The following apply to the acquisition of land by purchase.

1. The Department of the Army (DA) specifies to the appropriate Corps of Engineers district or division office that the Army needs land of a specified size in a specified area. The Corps then prepares and analysis "planning report" of the property and the general community. The DA decides whether to do this analysis in secret or with public knowledge.

2. The Corps consults the owner after the "planning report" is completed and asks his reaction to the possibility that DA will buy his land.

3. If the purpose is for an ongoing program and if the funds are available, approximately 90 to 120 days after the owner is contacted, an appraisal of the value of the land is made and an offer is made to the owner.

4. If the owner accepts the offer, he is required to vacate the land no later than 90 days after receiving payment. However, according to PL 91-646, if he so desires, the owner must be able to secure an adequate replacement for the property in the near vicinity. If he cannot find a replacement, either the purchase action can be stopped, or the government may have to build or acquire comparable housing or farmland for the displaced individual.

For the acquisition of land by condemnation, the following points apply.

1. If the owner refuses the government's offer for his property, a condemnation suit must be filed by the government against the land owner in order to obtain the property.

2. The government deposits in Federal Court an amount equal to their final offer to the land owner and legally takes possession of the land on the day of the cash deposit.

3. The period between the government's deposits and its physically taking possession can be 90 days or more.

4. Any changes in the property that decrease its value are substracted from the deposited sum.

Functional Area — Procurement.

Relevant References.

1. AR 30-13 Introduction of new or improved sustenance items into the military supply system.
2. AR 32-5 Introduction of new clothing and textile items into the DOD supply system.
3. AR 37-20 Administrative control of appropriated funds.
4. AR 37-42 Full funding of Army procurement programs.
5. AR 37-120 Procurement of equipment and missiles, Army (PEMA) management accounting and reporting system (PEMARS).
6. AR 60-10 Exchange service — general policies.
7. AR 71-5 Introduction of new or modified systems/equipment.
8. AR 230-1 Nonappropriated funds and related activities.
9. AR 230-3 Department of the Army welfare fund.
10. AR 310-31 Management system for table of organization and equipment (the TOE system).
11. AR 310-34 Equipment authorization policies and criteria, and common tables of allowances.
12. AR 700-2 Defense Supply Agency (DSA).
13. AR 700-18 Provisioning of U.S. Army equipment.
14. AR 700-34 Management retention, and reporting of Army-owned industrial plant equipment.
15. AR 700-41 Defense Supply Agency procurement and supply relationships with the General Services Administration.
16. AR 715-8 Implementing procedures for purchase of supplies assigned to DSA under the DOD coordinated procurement program.
17. AR 715-12 Provisioning requirements for GSA procured items.
18. CIR 715-2 series Procurement information

19. ASPR Armed Services Procurement Regulations.
20. Executive Order 11602 9 June 1971.

Commentary. Equipping, provisioning, and resupplying of the modern Army is a monumental task. Hardware procurement budgets run approximately $3 to 4 billion per year; an additional $1 billion is spent on foodstuffs, common consumables (e.g., petroleum, oil, and lubricants), and repairable spare parts.

Procurement is accomplished over four categories: (1) principal items (e.g., aircraft, missiles, etc.); (2) secondary items (e.g., parts, supplies, food for mess halls); (3) utilities and services; and (4) nonappropriated funds procurement (e.g., purchases for service clubs, commissaries, post exchanges, etc.). Principal and secondary items procurement is shown graphically in Figure 11.

Principal item procurement can be subdivided into two parts: (1) the introduction of new equipment into the system; and (2) the continued procurement of existing authorized items. These funds come from an appropriation designated "Procurement Army."

The introduction of new equipment into the system begins with the establishment, by the Training and Doctorine Command (TRADOC), of performance requirements for the new item. Using the guidance from TRADOC, the Research, Development and Engineering Directorate of the Army Material Command (AMC) prepares specifications, builds and tests prototypes, and refines the specifications to the point that commercial manufacture of the item will meet the performance requirements. Upon completion of the specifications the item is placed in the President's budget for congressional approval and funding. After congressional approval

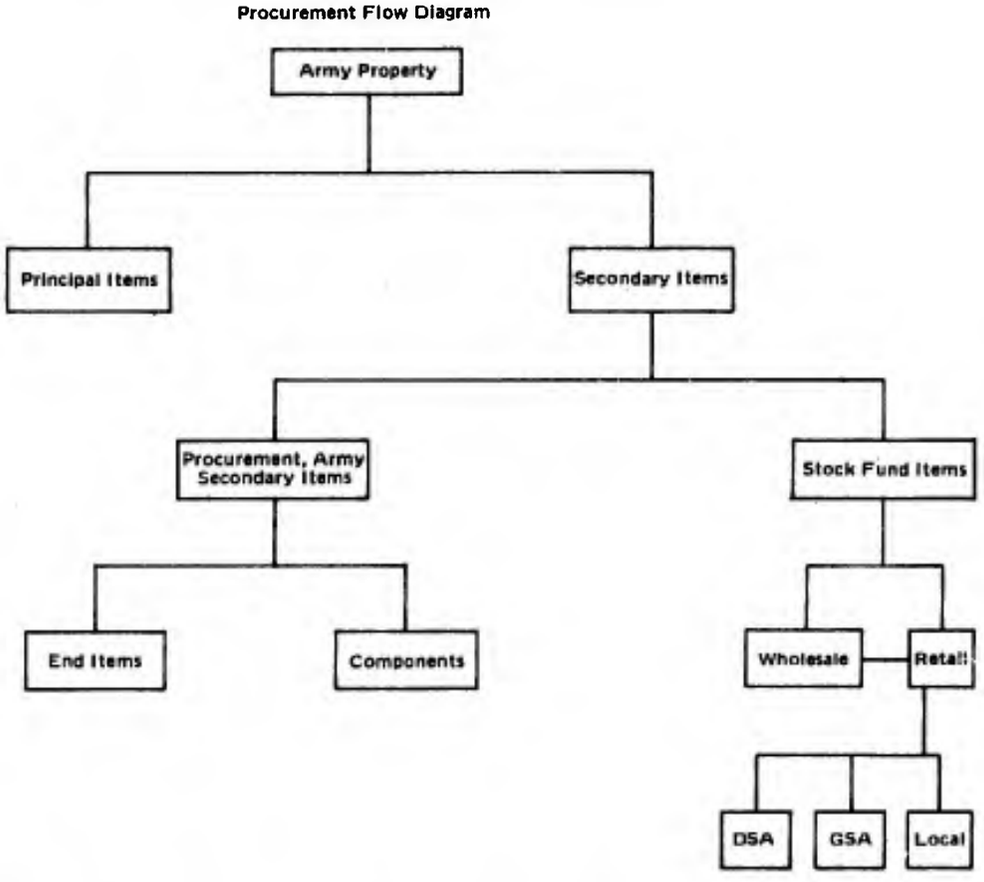


Figure 11. Relationship of Principal and Secondary Items Procurement in the Army

is received, the funds are released to the appropriate AMC command for procurement of the item. All procurement is accomplished in accordance with the Armed Services Procurement Regulations (ASPR). These regulations establish for the Department of Defense, uniform policies and procedures relating to the procurement of supplies and services under the authority of Chapter 137, Title 10, of the United States Code, or under other statutory authroity. These regulations apply to *all* purchases and contracts made by the Department of Defense, which obligate appropriated funds (including available contract authorizations), unless otherwise specified. Transportation services procured by transportation requests, transportation warrants, bills of lading, and similar transportation forms are not included.

The continuing procurement of existing items is accomplished on the basis of the differential between a quantity designated the Authorized Army Objective ((AAO) and the existing inventory. The AAO is composed of two parts: (1) the initial issue quantity (the sum of all the tables of organization and equipment (TOE) and tables of distribution and allowances (TDA) requirements, the maintenance float, and the pipeline or in-transit materials); and (2) the war reserves—the reserve quantities of each of the approved items which have been specified. The difference between the AAO and the existing inventory is the quantity for which appropriations are requested.

Procurement, Army secondary items include the following categories: (1) end items greater than $1,000 not classified elsewhere, or (2) components. End items are defined as items which can function by themselves without being attached to anything else. Components are those portions of end items which are nonexpendable but repairable at the depot maintenance level.

The Army stock fund is a revolving fund operation capitalized in excess of $2 billion. The stock fund is used to purchase expendable spare parts, clothing, textiles, food, petroleum, and office supplies either in wholesale quantities or from other government agencies and, then, sell these items to various installations.

The procurement of utilities and services such as power, water, refuse collection and disposal, and custodial services are accomplished under the provisions of ASPR.

Nonappropriated fund activities (open mess, welfare fund, chaplains funds, etc.) are not required to follow ASPR in their procurement activities. In all decisions determining whether procurement is by bid or by negotiation, the best interest of the fund must be served by the chosen method.

Post exchange activities are not covered by ASPR. A separate "exchange manual," reflecting many similarities to ASPR, is used as a guide. All procurement is accomplished by negotiating open-ended, fixed, unit-price contracts with name brand manufacturers. Individual exchanges then levy against these contracts for the quantities they desire.

Commissaries (grocery stores for military personnel) usually follow ASPR whenever possible, but they are technically exempt from the ASPR. The Defense Personnel Support Agency negotiates open-ended, fixed, unit-cost contracts with name brand suppliers to provide for the desires of the commissaries' clientele.

In most instances, under the provisions of ASPR, the low bidder who has the capability to perform the terms of the contract gets the contract. This basic principle of the ASPR can be modified to allow direction of contracts to labor surplus areas or to exclude big business and allow contract competition among small businesses (small business set aside).

Procurement for the hardware is provided for through five procurement appropriations: missiles, aircraft, ammunition, weapons and tracked combat vehicles, and other procurement. Any requirement for individual or group environmental assessment statements associated with hardware procurement is made more difficult by several factors exemplified in the following statements. At the time of submission for the annual procurement appropriation, the ultimate manufacturer as well as the plant location is unknown. Assessment of the potential environmental impact of hardware, when the manufacturer and the plant condition is unknown, is not as accurate as assessment of some other functional areas. However, when the general methods of manufacture are known, the environmental impact of those methods can be estimated.

Executive Order 11602, 9 June 1971, prescribes a program to assure that each federal agency empowered to enter into contracts for procurement of goods, materials or services, shall undertake such procurement in a manner that will result in effective enforcement of the Clean Air Act. Provisions by

which the Army can insist or enforce that the contractor and his subcontractors will meet existing pollution regulations are being developed for inclusion in ASPR. However, the low bidder concept may favor the manufacturer located in an area where pollution laws are inadequate or are indifferently enforced. The regulations prescribing Army procurement procedures may themselves be major actions significantly affecting the quality of the human environment if the regulations preclude the environment from being a legitimate consideration in the decision-making process.

Examples of Typical BAAPs. The following are typical examples of policies which might be proposed. The environmental effects of all policies must be considered before a decision is made.

PROCUREMENT POLICY
- PROCUREMENT OF GOODS NORMALLY WILL BE FROM THE LOWEST QUALIFIED BIDDER WHOSE PERFORMANCE CAPABILITIES HAVE BEEN VERIFIED
- NO PROCUREMENT IS PERMITTED FROM CONTRACTORS CONVICTED OF VIOLATIONS OF POLLUTION LAWS (EXECUTIVE ORDER 11602)
- PROCUREMENT WILL BE PROMULGATED IN A MANNER THAT WILL INSURE COMPLIANCE WITH THE CLEAN AIR ACT (EXECUTIVE ORDER 11602)

PROCUREMENT OF PRINCIPAL ITEMS
- AIRCRAFT
  - FIXED WING
    - LIGHT OBSERVATION
    - CARGO AND TROOP TRANSPORT
    - COMBAT SUPPORT
  - ROTARY WING
    - LIGHT OBSERVATION
    - CARGO AND TROOP TRANSPORT
    - COMBAT SUPPORT
    - HEAVY LIFT (FLYING CRANE)
- WEAPONS
  - CREW-SERVED
    - MACHINE GUNS
    - MORTARS
    - RECOILLESS RIFLES
  - INDIVIDUAL
    - PISTOLS
    - RIFLES
    - GRENADE LAUNCHERS

The following guidance was provided to the scientists in evaluating the impact of BAAPs associated with procurement.

In procurement, scientists should evaluate the list of BAAPs on the basis of the effect of Army expenditures on the environment. That is to say, for a wide variety of goods, which the Army procures, dollars flow from the government to the civilian sector to purchase the goods. Identify the possible environmental impact (direct and indirect) of the civilian activities supported by Army procurement funds. In addition, the environmental impact of manufacturing the goods (whether done in the civilian or at Army facilities) must also be evaluated. Any mitigating actions the Army could take to reduce the adverse environmental impacts should also be identified. Utilization of the goods will be evaluated for environmental impact in the operation, maintenance, and repair Functional Area.

Functional Area-Army Industrial Activities. Under this functional area three categories are depots, arsenals, and ammunition plants. The list of BAAPs under this functional area is extensive. General comments on the three programs and a typical list of BAAPs are present.

Depots: Relevant References.

1. AR 37-18 Weapons/support systems cost categories and elements.
2. AR 55-8 Transportation of biological materials.
3. AR 55-52 Reports of peacetime and mobilization movement requirements for bulk petroleum, chemicals, acids and gases in liquid or gaseous form.
4. AR 55-203 Movement of nuclear weapons, nuclear components, and related classified nonnuclear material.
5. AR 55-228 Transportation by water of explosives and hazardous cargo.
6. AR 75-15 Responsibilities and procedures for explosive ordinance disposal.
7. AR 700 series Logistics.
8. AR 710 series Inventory management.
9. AR 711 series Stock control.
10. AR 725 series Requisition and issue of supplies and equipment.
11. AR 742 series Inspection of supplies and equipment.
12. AR 746 series Marking, packing, and shipment of supplies and equipment.
13. AR 755 series Disposal of supplies and equipment.
14. DA 701 series Logistics plans
15. DA 708 series Supply.
16. DA 740 1-1 Preservation and packing.
17. TM3 series Chemical.
18. TM 9 series Ordnance
19. TM 10 series Quartermaster.
20. TM 700 series Logistics.
21. TM 740 series Storage and shipment of supplies and equipment.

22. TM 750 series Maintenance of supplies and equipment.
23. Supply manuals.
24. Supply bulletins.

Depots: Commentary. Depots are government-owned, government-operated facilities under the control of the U.S. Army Materiel Command (AMC). Depots serve two distinct functions, storage and repair.

Each depot has a primary commodity storage assignment and at least one secondary storage assignment. For example, Red River Army Depot has the primary assignment of storing tactical vehicles (trucks, jeeps, etc.), and a secondary assignment of storing tracked combat vehicles. Storage is accomplished in facilities ranging from climate-controlled warehouses to uncovered storage yards.

The repair facilities can best be described as small-lot, assembly line operations. For example, a facility might have a lot of 50 tank engines to overhaul, to be followed by 150 trucks. The assembly line thus lacks the specialization and automation found in an automobile factory.

Whereas the commodity storage assignments are established by AMC, the repair jobs are apportioned on a modified bid process. Depots having the capability to repair an item will submit a unit-cost-to-repair bid to AMC. In this case, however, the lowest bidder with the capability to perform may not get the job. The competitors are scrutinized for such things as number of people on overhead, the possible need for reduction in force, and need for new equipment. The job is sent to the depot where it will do the most good, both from the aspect of job accomplishment as well as the maintenance of future capability to perform.

Arsenals: Relevant References.

TM 9-1300-214 Military Explosives.

Information presented herein was obtained by conversations with Army Materiel Command, Weapons Command, Munitions Command, Rock Island Arsenal and Picatinny Arsenal personnel, brochures from Rock Island and Watervliet Arsenals and the environmental impact statement for delilitarization operations at Rocky Mountain Arsenal. Information on metal casting and finishing was obtained from *Metals Handbook*;[18] information on machining was gleaned from *Modern Manufacturing Processes*;[19] and information on measurements of properties of explosive was extracted from TM 9-1300-214.

Arsenals: Commentary. U.S. Army Arsenals are government-owned, government-operated facilities under the Army Materiel Command (AMC).

Historically, arsenals were established for the manufacture, storage, and repair of weapons. The mission of the arsenal had changed in recent times. The storage and repair of most weapons as well as most ammunition has been transferred to depots. Weapons manufacturing capability still exists at the arsenals and periodically some weapons manufacturing or repair contracts are fulfilled at arsenals. Today, however, most weapons are procured from the commercial sector by contract. The arsenals have been assigned an R&D role.

Of the eight active arsenals, Detroit is under AMC's Tank-Automotive Command (TACOM). Watervliet and Rock Island are under the Weapons Command (WECOM), and the Munitions Command (MUCOM) controls Edgewood, Picatinny, Frankford, Pine Bluff, and Rocky Mountain. While full-weapons-spectrum, small-lot manufacturing capability exists at both WECOM arsenals, a division of specialty appears to exist wherein Watervliet deals with large-caliber weapons for the Army and Navy, while Rock Island handles smaller caliber weapons.

MUCOM has also created specialized commodity centers by delegating R&D responsibilities as follows: Edgewood—offensive and defensive chemical warfare; Picatinny—explosives, propellant, and loading; and Frankford—small arms ammunition and metal parts manufacturing.

Rocky Mountain and Pine Bluff arsenals are engaged in chemical demilitarization, with Pine Bluff having additional responsibility for R&D in smoke, flares, and pyrotechnics.

Some arsenals provide a home for nonarsenal/nonAMC activities; e.g., Army Environmental Hygiene Agency (Class II activity of the Surgeon General's Office) is housed at Edgewood and Picatinney is the home of MUCOM.

[18] *Metals Handbook* (American Society of Metals, 1964) Vol. 2.
[19] J. L. Morris, *Modern Manufacturing Processes* (Prentice-Hall, Inc. 1955).

Ammunition Plants: Relevant References.

1. Urbanski, T., *Chemistry and Technology of Explosives*, Pergamon Press, New York, 1967, Vols. 1, 2, & 3.[20]
2. Cook, M. A., *The Science of High Explosives*, Reinhold Publishing Company, New York, 1958.[21]
3. TM 3-215 Military chemistry and chemical agents.
4. TM 9-1300-214 Military explosives.
5. Installations Summary Listing (as of 1 January 1972), Installations and Services Directorate, AMC.

Ammunition Plants. *Commentary.* Ammunition plants are government-owned, contractor-operated facilities responsible through the Army Ammunition Procurement and Supply Agency (APSA) and the Munitions Command (MUCOM) to the Army Materiel Command. Eighty percent of the explosives used by the U.S. Armed Forces are produced in Army ammunition plants.

Most contracts with the contractor simply call for the maintenance of the physical plant. Explosives production is accomplished via amendments to the basic contract. Among plants producing the same product, a modified bidding procedure (similar to that between depots) is carried out to determine the supplier of the particular quantity requirement. Procurement of the raw materials for ammunition production is the responsibility of the contractor. Procurement is made from the civilian economy and is technically independent of the Armed Services Procurement Regulations (ASPR).

Plant safety programs are actively pursued at the plants. Quantity-distance ratios are fixed to reduce the possibility of explosion. Where distance cannot be met, barricades are erected between the buildings to minimize the propagation of explosions between buildings. All floors in explosives buildings are kept wet to reduce the chance of spark. Smoking is permitted only in certain areas. No matches are allowed in the manufacturing area. Protective devices and safety chutes abound and evacuation plans are prominently displayed in all occupied buildings.

[20] T. Urbanski, *Chemistry and Technology of Explosives*, Vol. 1, 2, and 3 (Pergamon Press, 1967).
[21] M. A. Cook, *The Science of High Explosives* (Reinhold Publishing Company, 1958).

Examples of Typical BAAPs.

DEPOT ACTIVITIES
- DEPOT SUPPLY OPERATIONS
  - GENERAL
    - MOVEMENT AND TRANSPORTATION ACTIVITIES
    - UTILITIES USAGE
    - PEOPLE MOVEMENT
    - MATERIALS HANDLING
    - INVENTORY CONTROL
    - BIN REPLENISHMENT
    - CLERICAL SUPPORT
    - COMMUNICATIONS USE
  - STORAGE AND WAREHOUSING
    - RECEIVING
    - LOADING AND UNLOADING
    - UNPACKING
    - INSPECTION
    - STORE ELECTRONIC MATERIAL
    - STORE MISSILES
    - STORE TACTICAL VEHICLES (JEEPS, TRUCKS, ETC.)
    - STORE COMBAT VEHICLES (TANKS, APCs, SELF PROPELLED ARTILLERY)
    - STORE MIXED EQUIPMENT (CONSTRUCTION EQUIPMENT GENERATORS, ETC.)

ARSENAL ACTIVITIES
- MANUFACTURE WEAPONS
  - FOUNDRY OPERATIONS
    - RECEIVE FERROUS AND NONFERROUS METAL BILLETS
    - RECEIVE CASTING SAND (QUARTZ OR SILICA AND CLAY)
    - CONSTRUCT MODEL OF PART TO BE CAST
    - PREPARE MOLD (PACK SAND AROUND MODEL, REMOVAL OF MODEL, INSERT CORES)
    - MELT METAL OR ALLOY
    - ADD VOLATILE METALS OR ALLOYS TO MEET REQUIRED COMPOSITION
    - POUR MOLTEN METAL INTO MOLD
    - CENTRIFUGALLY CAST (ROTATING MOLD CAUSES MIGRATION OF IMPURITIES TO CENTER FOR REMOVAL BY BORING)

AMMUNITION PLANTS
- MANUFACTURE NONINITIATING HIGH EXPLOSIVES
  - MANUFACTURE TNT
    - NITRATE TOLUENE IN THREE STAGES (NITRATING ACID PASSES COUNTER-CURRENTLY FROM TRI-TO-MONO-NITRATOR
    - USE MIXED ACID CONTAINING (INITIALLY) 82 PERCENT SULFURIC ACID (INCLUDES 5 PERCENT EXCESS FOR DEHYDRATION DURING REACTION) AND 23 PERCENT NITRIC ACID
    - DISCHARGE SPENT ACID CONTAINING SULFURIC, NITRIC, NITROSYL-SULFURIC ACIDS AND NITROBODIES

PURIFY TNT BY WASHING WITH SODIUM SULFITE SOLUTION
REMOVES NON ALPHA ISOMERS OF TNT AND TETRANITROMETHANE) TREAT WASH SOLUTION (RED WATER) BY INCINERATION (RECOVER IMPURE SODIUM SULFITE-MARKET WHERE POSSIBLE)

Functional Area—Research, Development, Test, and Evaluation (RDT&E).

Relevant References.

1. AR 70-9 Army research and development information systems program - planning and on-going work reporting.
2. ER 70-3-6 Management of military construction and military engineering and topography research and investigation program.
3. NASA Thesaurus, N68-11307, distributed by clearinghouse for federal scientific and technical information.
4. *Thesaurus of Engineering and Scientific Terms*, Department of Defense (1967).

Commentary. There are approximately 100 laboratories and test facilities in which the Army conducts basic and applied research and evaluates test results. In attempting to evaluate the potentially damaging activities associated with each of these installations, the scientists examined a list of RDT&E projects approved for FY 72. This was considered to be a representative or typical year. The list indicated the title of the project, its funding level (if not classified), and a numerical cost code (see Program Funding) which indicated the nature of the effort. Those programs whose codes indicated that they are in the basic research or exploratory development stages (Sec. 6.1 - Research and 6.2 - Exploratory Development Projects AR 70-95) were identified, and this was taken into consideration in rating the potential impact. Those projects in advanced or engineering development stages, or those involving the management and support of test centers were usually considered to have greater potential impact.

The projects in which the scientists expressed greatest concern with regard to their impact, involved development and testing of both lethal and incapacitating chemical agents. Details of this work are classified; therefore an attempt was made to clarify the exact items of the programs where the environmental impact may be anticipated. A detailed list of likely activities was generated by personnel with some knowledge of the general area, but lacking privileged information from any Army facilities. The list of activities is therefore not exact. It probably does include the most common predictable activities, including likely accidents. The remainder of the list of RDT&E activities, consists of a group of common testing procedures known to be used in many installations. Many of the items are admitted to have several meanings in a broad range of disciplines, and this variety of meanings was taken into account in evaluating impacts.

One aspect of testing procedures deserves discussion. When items undergo preliminary testing for production acceptance, the impact of this test procedure usually differs little from that of training or other normal use. The impact would probably be smaller in most cases, since only very small numbers of the items would be used. For example, the testing of a new vehicle would differ little from the use of older vehicles in training or transportation, unless it were a radically new type. This is not generally the case. Testing of new types of weapons, also, would differ little in overall impact from the use of existing weapons in training operations. Thus, unless the testing is done in a different area, or involves completely different types of materiel, the impacts should be sought under the appropriate category in the section on training.

Program Funding. Research, development, and investigational programs funded through RDT&E monies are applied to the following effort categories (AR 70-9):

6.1 Research: Directed to the development of fundamental knowledge.

Includes scientific study and experimentation directed toward increasing knowledge and understanding in those fields of the physical, engineering, environmental, biological-medical, and behavioral-social sciences related to long-term national security needs. It provides fundamental knowledge for the solution of identified military problems. It also provides part of the base for subsequent exploratory and advanced developments in defense-related technologies and of new or improved military functional capabilities in areas such as communications, detection, tracking, surveillance, propulsion, mobility, guidance and control, navigation, energy conversion,

materials and structures, and personnel support.

6.2 Exploratory Development: Directed to the development of new techniques, methodologies, and criteria.

Includes all effort directed toward the solution of specific military problems, short of major development projects. This type of effort may vary from fairly fundamental applied research to quite sophisticated breadboard hardware, study, programming, and planning efforts. It would thus include studies, investigations, and minor development effort. The dominant characteristic of this category of effort is that it be pointed toward specific military problem areas with a view to developing and evaluating the feasibility and practicability of proposed solutions and determining their parameters.

6.3 Advanced Development: Concerned with design and development of hardware (materiel) items for experimentation.

Includes all projects which have moved into the development of hardware for experimental or operational test. It is characterized by line item projects and program control is exercised on a project basis. A further descriptive characteristic lies in the design of such items being directed toward hardware for test or experimentation as opposed to items designed and engineered for eventual service use.

6.4 Engineering Development: Directed to testing and demonstration of new techniques or methodologies, and to technical systems equipment.

Includes those development programs being engineered for service use but which have not yet been approved for procurement or operation. This area is characterized by major line item projects and program control will be exercised by review of individual projects.

6.5 Management and Support: Directed to the support of installations for their operations and maintenance and for the procurement of special purpose equipment.

Includes research and development effort directed toward support of installations or operations required for general research and development use. Included would be test ranges, military construction, maintenance support of laboratories, operation and maintenance of test aircraft and ships, and studies and analyses in support of the R&D program. Costs of laboratory personnel, either in-house or contract operated, would be assigned to appropriate projects or as a line item in the research, exploratory development, or advanced development program areas, as appropriate. Military construction costs directly related to a major development program will be included in the appropriate element.

Examples of Typical BAAPs.

CHEMICAL AND BIOLOGICAL RESEARCH
- BASIC (CONTROLLED LAB CONDITIONS)
  - DISPOSAL OF SPENT HEAVY METALS
  - DISPOSAL OF CONTAMINATED FILTERS
  - CONSUMPTION OF ENERGY
  - OPERATE LAUNDRY FOR CLEAN ROOM
  - OPERATE CLEAN ROOM
  - DISPOSAL BY PATHOLOGICAL INCINERATION
  - DISPOSAL OF COLORED (DYED, (STAINED)
    - WATER WASTE
  - LABORATORY ACCIDENTS
- TESTING EFFECTIVENESS (CONTROLLED LAB)
  - DISPOSAL OF ANIMAL WASTES
  - ACCIDENTS
    - ESCAPE OF TEST ANIMALS
    - DROPPING THE TEST AGENT

PROVING GROUND
- DISPOSAL OF CONTAMINATED ANIMAL CARCASSES
- DISPERSAL OF THE AGENT
  - BY AIRCRAFT
  - BY GAS GENERATORS

Functional Area — Administration and Support

Relevant References.

1. AR 1-21 Administration space management.
2. AR 1-50 Work measurement.
3. AR 5-3 Doctrine and philosophy for management for class 1 installations.
4. AR 18-3 Automatic data processing management information system.
5. AR 27-10 Military justice.
6. AR 65-10 Use of Army postal service.
7. AR 210-10 Administration (installations).
8. AR 360-5 General policies (Army information.
9. AR 600-8 Military personnel offices.

10. AR 600-20 Army command policy and procedure.
11. AR 600-21 Equal opportunity and treatment of military personnel.
12. AR 600-40 Apprehension, restraint, and release of civil authorities.
13. AR 600-50 Standards of conduct for Department of the Army personnel.
14. AR 600-200 Enlisted personnel management system.
15. AR 614-6 Permanent change of station policy.
16. AR 614-30 Overseas service.
17. AR 614-100 Officers.
18. AR 614-200 Enlisted personnel selection, training, and assignment system Grades E-1 through E-9.
19. AR 690-1 Civilian applicant and employee security program.
20. AR 870-5 Military history: responsibilities, policies, and procedures.

Commentary. Administration and support, as one might expect, cover those functions which are required to make a facility, or office, or organization function in a coherent manner. Many of the activities of administration and support are covered under other functional areas.

Examples of Typical BAAPs.

ADMINISTRATION PROGRAM
- EXECUTIVE OFFICE ACTIONS
  - ISSUANCE OF ORDERS AND GUIDANCE
  - HIRING AND FIRING
  - PUBLIC COMMUNICATIONS
    - PUBLIC SERVICES
    - COMMUNITY RELATIONS
    - SPECIAL RELATIONS (SCHOOLS, FIRE PROTECTION, PUBLIC HEALTH)
- PERSONNEL SERVICES
  - CAREER MANAGEMENT INCLUDING:
    - TRAINING
    - STEP AND GRADE PROGRESSION
    - JOB ROTATION AND ASSIGNMENT
  - SPACE ALLOCATIONS
  - PERFORMANCE EVALUATION
  - SAFETY
  - INSURANCE PROGRAM (GROUP HEALTH, GROUP LIFE
  - CIVILIAN WELFARE FUND
  - INTELLIGENCE SECURITY INVESTIGATIONS
  - RETIREMENT PROGRAM

4 SCIENTIFIC TECHNICAL SPECIALTIES

Due to the variety and abundance of information collected for this study, it was deemed necessary to standardize and summarize the scientists' output. In this section the following format will be used for each technical specialty:

1. Introductory commentary;
2. Selected detailed attributes;
3. Selected review level and controversial attributes; and
4. Selected ramification remarks and mitigation procedures.

The introductory commentary serves to answer the following questions:

1. What is the role of the technical specialty in environmental research?
2. How were the attributes developed?
3. What interactions might typically occur between this technical specialty and other specialties?
4. What are some typical attributes for the technical specialty?

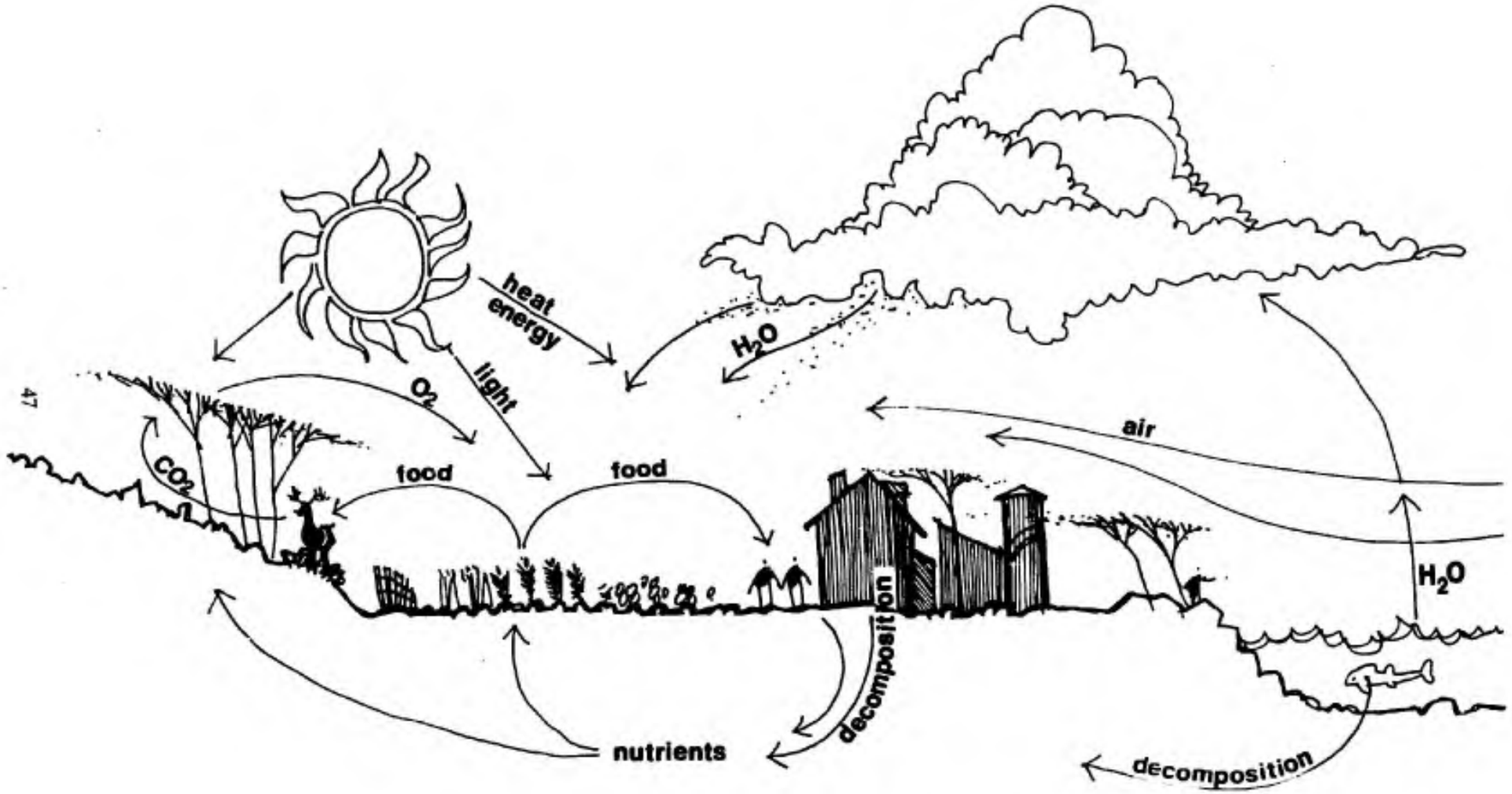
Following this section a short list of detailed attributes and descriptors is included for exemplary purposes. These attributes were not selected for any specific purpose other than to aid the reader in understanding the quality of the system output.

The next section discusses selected review level and controversial attributes, again only for exemplary purposes.

Finally, selected ramification remarks and mitigation procedures are shown. The examples shown are taken from the construction functional area's interaction with each technical specialty.

Ecology.

Introductory Commentary. Interest in plant and animal species, especially those which seem to be getting less common, prompted the beginnings of modern environmental concern in the mid 1950s. The general recognition that man was seriously disturbing organisms in the ecosystem without intending to do so, caused ripples of concern, disbelief, and protest which are still with us. While it has always been recognized that many species have been crowded out of their habitats, and that others have been deliberately exterminated, the gradual comprehension of the fact that man was killing many species, especially through use of broad-spectrum pesticides, came as a distinct shock to the scientific community. Even greater public controversy was



ENERGY CYCLES IN THE ECOSYSTEM

generated by semi-popular groups which actively pressured governmental agencies for enactment of legislation to prevent recurrence of such widespread detrimental impacts. Modern legislation requiring assessment of likely effects before initiation of a project is an outgrowth of these movements of the 1960s.

It is generally agreed that an aesthetically agreeable environment includes as many species of native plants and animals as possible. In many ways, one may measure the degradation of environments by noting the decrease in these common wildlife species. Since many types of outdoor activities are based directly on wildlife species, there may be economic as well as moral and aesthetic bases for maintaining large healthy populations. The values derived from hunting and fishing activities are the difference between existence and relative affluence for many persons engaged in services connected with these outdoor recreational pursuits.

While pollution is a part of the vocabularly of most persons these days, it affects seriously the lives and health of only a very few human beings directly. What we must realize, however, is that humans are subject to the same biological laws as the wild species around us. The accumulation of poisonous chemicals that cause the fish in a stream to die could act exactly that same way on the human body. Fortunately, the human physiology is more resistant to these chemicals than are most other animals. Many scientists agree that we must see in the effects on other animal and plant species a warning, possibly somewhat similar to the canary once carried into the mines to serve as a warning to the miners of accumulations of gas. Once the other species are affected, the threshold for man cannot be far away.

In the process of development of attributes encompassing biology and ecology, the scientists in these disciplines determined that there exist at least three separable types of interests. These interests formed the basis for attribute development as shown in Figure 12. The first, *species diversity*, includes all types of plants and animals considered as species, whether or not it can be determined that they have economic importance or any other special values. It was felt that information could be input here from scientists whose major interests are in a particular species or small group of organisms, but who may lack knowledge of their ecological relationships.

The second general area consists of factors grouped under *system stability*, which is basically concerned with synthesis of relationships among the various organisms within a community. Most of the truly ecological relationships may be found here, and scientists whose interests and information deal with community relationships can contribute to knowledge within this area. Detailed analysis of such ecological attributes is very time consuming and requires very experienced personnel and, often, specialized equipment.

Wildlife management is the last area separated within ecology/biology, and deals with species known to have some recreational and economic value. These species are usually managed by state or other conservation departments, and the hunting and fishing they generate may be of considerable local or regional economic importance. Each of the attributes given was deemed to be different enough in its intrinsic characteristics and in the ways in which environmental impacts are expected to act that it deserved separation from the others.

All the areas in ecology are very difficult to quantify, often being almost impossible to present in terms familiar to scientists in other disciplines. Furthermore, there are literally millions of possible pathways in which interactions among the plants, animals, and environment may proceed. To date, scientists knowledgable in the field have been able to trace and analyze only a small minority of these, though thousands more may be inferred from existing data. Thus many of the impacts predicted cannot be absolutely verified. Others are probably correct by comparison with known cases involving similar situations, while many more are simply predicted on the basis of knowledge and experience in a broad range of analagous, though not closely similar, systems.

The question of chance effects is also an important one in ecology. One may be able to say that the likelihood of serious impact following a certain activity is low, based on available experience. This is definitely *not* the same as saying that the impact, if it develops, is not serious. The impact may be catastrophic, at least on a regional basis, once it develops. When one works with living organisms, too, the possibility of spread from an area where little chance of damage exists to one in which a greater opportunity for harm presents itself is a very real danger. The vectors of such movement cannot be predicted with any accuracy; however, the basic principles best kept in mind are simple enough. Any decrease in species diversity tends to also decrease

the stability of the ecosystem, and any decrease in stability increases the danger of fluctuations in populations of economically important species.

Many other scientific disciplines are often closely related to biology. When the question of turbidity of the water in a stream is examined, for example, it will be found that this effect is not only displeasing to the human observer, but has ecological consequences also. The excessive turbidity may cause eggs of many species of fish to fail to develop normally. It may even, in extreme cases, render the water unsuitable for the very existence of several species of fish. The smaller animals and the plant life once characteristic of that watershed may also disappear. Thus the turbidity of the water, possibly caused by land-clearing operations along the banks upstream, may have effects ramifying far beyond the original observed ones. Similarly, almost all effects which are observed relating to the quality of water will also have some ecological implications in addition to those already of interest from a water supply point of view.

Since it was the observation of damage to the biological environment that was the cause of most of the interest in ecology in the past decade, we must recognize that there is almost no activity which takes place which does not have some ecological implications. These may be simply aesthetic in nature, damaging the appearance of a favorite view, for example. They may also be symptoms of effects which could also be harmful to man if left alone for the years to come, such as pesticide accumulation by birds and fish. If we are to view the area of biology, or ecology, in perspective, we must realize that it includes a wide variety of messages to man. These should be interpreted as skillfully as possible if man's future is to be assured.

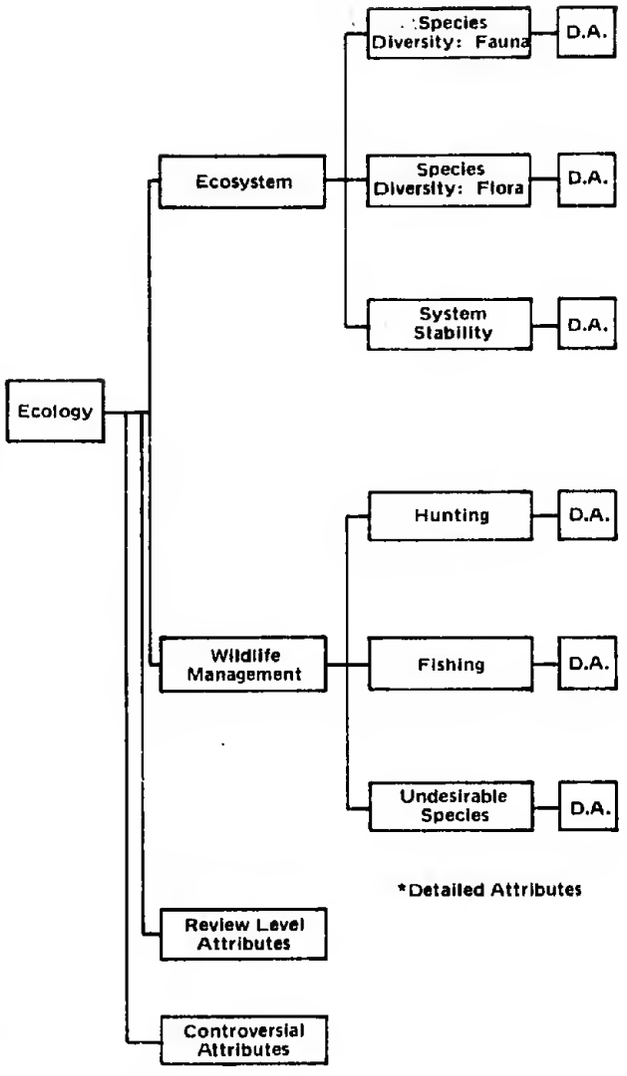


Figure 12. Attribute Hierarchy for Ecology

Review Level Attributes. Forest: Ecosystems consist usually of trees, shrubs, herbs, and lower plants such as mosses and lichens, and animals such as large and small mammals and birds. The trees usually form the canopy of the forest thus controlling its environment with regard to light, humidity, wind, and soil moisture. A mature forest is a complex, highly organized ecosystem whose components are interdependent and the removal of a component influences other components. For example, if the trees are cut most of the seedlings and some of the saplings will probably die. This is due to the change in their environment from shady and moist to a sunny, probably dry environment to which they are not adapted. With the removal of trees some species of birds would also disappear since they nest and feed at various levels of the forest. Furthermore, the removal of trees may lead to the leaching of nutrients and sometimes soil. These nutrients, especially those removed by surface water, may get into streams thus raising the level of its nutrients to a degree that may initiate eutrophication. As a result, not only the forest ecosystem is destroyed but also the stream ecosystem which may be spatially removed from the forest may be impacted.

Examples of Typical Detailed Attributes.

SMALL MAMMALS

A.

Small mammals are those massing less than about 15 kg as adults. Rabbits, foxes, squirrels, racoons, mice, and moles are examples of small mammals.

B.

Small mammals are often very tolerant of human activity, living quite close to buildings so long as suitable food and living space is available. The most damaging human activity with respect to small animals is habitat destruction. Without proper cover, populations disappear quickly. In a few cases, poisons intended for insects or predators have killed very large numbers of small mammals accidentally.

C.

Forest and brush clearing, herbicidal control of scrub trees and weeds, and widespread weed mowing of idle lands are examples of activities which decimate populations of most small mammals. Widespread insect and predator control programs, especially those involving distribution of poisoned baits, are almost always very destructive of nontarget small mammals.

D.

Some small mammals, e.g., rabbits and squirrels, are the basis for considerable hunting activity. These and most other species are also very basic links on the food chain of predators such as hawks, foxes, and wild cat species, and as such are vital to their existence.

EXAMPLE OF ECOLOGICAL DETAILED ATTRIBUTE
CONTRIBUTING TO SPECIES DIVERSITY

CLIMAXNESS

A.

Climaxness is an evaluation of the present likelihood of change in a natural system. If a system has stability enough to allow for indefinitely continued successful reproduction of all species present, while excluding all new potential invaders, then it is said to be a climax community. Area occupied by genuinely undisturbed climax communities is relatively uncommon.

B.

Any activity which results in the loss of an important species or the introduction of an exotic species may cause changes to take place in a previously stable area. Significant changes in nonliving components, such as available nutrients, may also have this effect.

C.

Timber sales, overgrazing by livestock, land clearing for construction, herbicide application, drainage of wet lands, decrease in stream flows, addition of untreated sewage to waterways, and overfertilization o managed lands are all examples of activities which have been known to result in rapid change in previously stable natural systems.

D.

Existing climax areas are quite rare, and often small in extent. Aside from historical interest in what the country was like before man disrupted it, considerable scientific knowledge remains to be obtained from these areas. For example, it would be desirable if agriculturists could study the ways in which the native plants and animals interacted to form the remarkably rich soil found in the prairie regions of Illinois. They cannot do so because no really undistrubed prairie of adequate size remains for study.

EXAMPLE OF ECOLOGICAL DETAILED ATTRIBUTE
CONTRIBUTING TO SYSTEM STABILITY

HUNTING — MIGRATORY WATERFOWL

A.

Migratory waterfowl include geese, ducks, and other related birds, the hunting of which requires purchase of the annual federal migratory bird stamp.

B.

Activities which either create or diminish bodies of water may alter resting, reproduction, and overwintering patterns of these species. In areas known to have significant populations of waterfowl, alterations in crop production patterns and clearing of some types of natural grass species may affect food supplies, as may some insect control measures.

C.

Dams, drainage of wetlands, insect controls, building of dikes and levees, dredging of channels, defoliation, and some types of overland exercises are examples of activities which could be expected to affect this attribute.

D.

Adverse conditions are known to reduce both success of reproduction and tendency toward "stopover" choices during the (fall) hunting season. Both result in a smaller crop of waterfowl available for harvest in the local area. An extensive alteration of a nesting area may cause reduced crops of birds in subsequent months and seasons over a multistate area. Accumulations of insecticides are known to be detrimental to reproductive success, and are sometimes acutely toxic.

EXAMPLE OF ECOLOGICAL DETAILED ATTRIBUTE
CONTRIBUTING TO WILDLIFE MANAGEMENT

FISHING — POND AND RIVER

A.

Pond and river fishing includes fishing for species such as bass and the various sun fish in relatively quiet, warm inland waters.

B.

Any activity leading to increased or decreased water levels, erosion and siltation, and changes in stream flow can affect the magnitude of this sport fishing resource. Chemical waste disposal and biocidal programs may also interfere with reproduction of these species.

C.

Dams, dredging, channel improvements, and any other shoreline earth-moving activities may affect these species. Creation of impoundments in suitable areas can create new fishing sites. Large-scale biocidal programs on a watershed may decrease reproduction and food supplies. Chemical disposal may lead to accumulation of heavy metals in quantities potentially dangerous to the humans eating fish regularly.

D.

Fishing of this type is widely popular and damage to this resource would be accompanied by wide public indignation. In some resort areas, considerable income is generated by fishermen in this category.

EXAMPLE OF ECOLOGICAL DETAILED ATTRIBUTE
CONTRIBUTING TO WILDLIFE MANAGEMENT

Ground Cover: This may be taken to mean low vegetation usually consisting of grasses and/or broad-leaved herbaceous plants and small shrubs, as well as lower plants such as mosses and lichens, which grow on the soil thus offering a cover, or a mantle over it.

Ground cover may also include layers of undecomposed leaves, twigs, and other plant remains which accumulate above the mineral soil surface.

Ground cover serves several important functions in ecosystems.

1. It supplies food and offers shelter to a variety of animals from mammals, birds, reptiles, etc.

2. It serves as a protective cover against soil erosion.

3. It ameliorates the soil environment with regard to depth of frost, temperature fluctuation, and moisture regimes.

4. It offers suitable sites for germination of seeds of other plant species thus maintaining the structure of climax communities and/or accelerating succession toward these communities.

The removal of ground cover by clearing, burning, and other similar activities will certainly have detrimental consequences on the ecosystem. This is especially true in areas with extreme environments such as pronounced temperature fluctuations, heavy rainsall and steep slopes.

Game Animals: Those species of birds and mammals whose numbers are managed primarily with regard to their value in sport hunting are called game animals. It is necessary to have a hunting license to shoot or trap them, and every state has employees whose duty involves adjustment of bag limits and hunting season dates so that huntable populations of these animals are perpetuated.

Examples of game animals are many, including deer, elk, rabbits, quail, pheasant, ducks, and dozens of others in various parts of the country. Many millions of persons engage in sport hunting every year, and the economic value of hunting and related purchases is significant in most parts of the country and is very important in several. The income from hunting licenses finances most state game departments, making professional management of game species, as well as other wild species, more economically feasible than it might otherwise be. Federal taxes on guns and ammunition raise the equivalent of a major part of the budget of those federal agencies charged with management of wildlife refuges and game management areas. The federal government also requires a fee (tax) in addition to a state hunting license for taking of migratory waterfowl, this tax bringing in several million dollars each year for wildlife uses.

Ecologically, hunting is a valuable contribution to the majority of present communities. Most major predators were eliminated a century ago in the settled parts of the United States. In their absence, it is possible for many smaller species to proliferate far beyond the safe carrying capacity of the habitat. Man must fill the role of a predator, removing a number of animals each year so those remaining are assured an adequate food supply during the periods of stress, usually in winter. Contrary to what might be popularly believed, no aminal species seems to have been seriously endangered by *sport* hunting. On the other hand commercial hunting of may species for pelts, horns, and meat for *sale* has been very destructive in many cases.

Game Fish: Those fishes commonly taken for sport on hook and line are the game fish. They range in size from eight-ounce sunfish to several-hundred-pound tuna. The gear which is used ranges from the traditional cane pole to ocean-going boats with special trolling equipment. While many of the species taken are eaten, just as many are returned to the water. Most states require a fishing license and further restrict the species and numbers which may be taken from any given body of water.

Bass, trout, salmon, pike, and the sunfish are a few examples of the many game fishes sought in the United States. Their pursuit involves expenditures of several million dollars annually by fishermen, and this income is of major importance to many communities in good fishing areas. Income from fishing licenses also adds to the funds available for the states' use in management of fish hatcheries and other management areas.

Sport fishing has not been known to have caused the extinction, or even endangerment, of any species of fish. Rather, the lack of fishing pressure on some waters, especially artificial impoundments, has led to abnormal distribution of size and age classes of some fish species. Present theory suggests that steady sport fishing pressure is beneficial to almost all bodies of water.

Rare and Endangered Species: These are

species of plants and animals which are restricted to small specialized habitats or whose populations are declining because of natural causes or because of human activities such as removal of vegetation for urbanization, use of insecticides and other chemicals, pollution of air and water and overhunting. Examples of these are the redwoods of California and the bald eagle. There are many species, especially in the plant kingdom, that qualify for this category; however, the public awareness of them is not as great as its awareness of endangered animal species. The disappearance of these species represents, in addition to the esthetic or other intangible value, a loss of ecosystem components which may have important niches essential to the proper functioning of these ecosystems. The difficulties of assessing the consequences of the removal of these species from ecological systems is sometimes insurmountable since the role of these organisms may not be readily obvious even to trained specialists. Furthermore, the genetic information which is carried by these organisms would be lost forever if they are completely eliminated. From an evolutionary point of view this may represent a loss of genetic information which was assembled through millions of years of evolution to make an organism well suited to the environmental attributes of its habitat.

Controversial Attributes. There are three general areas of concern here; problems which will cause public indignation and which might arouse scientific condemnation. They are impacts on game animals, encroachment on natural habitats, and rare and endangered species.

It is clear from experience that the areas involving *game fish and animals* lend themselves to public interest. Any activities which might be construed as being detrimental to hunting or fishing in a local area will immediately arouse strong protest against the damage, real or imagined. Specific areas might involve maneuvers in recognized big-game habitat, amphibious assaults in areas of known surf or shellfishing interest, and damming or silting streams which produce fishable trout populations.

Most professional biologists would recognize that the major game species are generally not in direct danger from Army activities, with the possible exception of the degradation of trout streams, in which good quality water has no substitute. The professional biologist should, rather, be aware of threats to really rare species and also to the gradual *reduction of habitat* available to the common species. In both cases, the threat seems to come mainly from the continued encroachment of civilization in areas once deemed too remote or too marginal for development. Whether this development and subsequent expulsion of native species has taken place as a result of the official policies of the govenment or as a result of the commercial interests generated by military developments is of little consequence in the long run. The net result is the same.

There is much reaction from the moderately well-informed general public to proposed projects and activities concerning the possibility that such actions might affect the small remaining populations of those plants and animals which are *rare and endangered.* It was almost entirely public sentiment which led to the relative success of the banning from commerce of products from animals which were officially considered endangered. When conspicuous and sentimentally attractive animals such as tigers, grizzly bears, and even giant pandas become so uncommon in the wild that they are unable to reproduce successfully, then the controversy surrounding a proposal which might further reduce their populations is one of the hottest topics around. Witness the prompt alteration of a proposed purchase of thousands of wolf-fur fringed parkas by the government. The future will see only an increase in the number of species considered interesting enough and rare enough that the sentiments of the public will protect them from danger. A few plant species are already candidates for this popular interest, especially the coast redwood. Others seem certain to gain status in the mind of the informed and active public.

Selected Ramification Remarks and Mitigation Procedures. The following examples illustrate ramifications of an activity beyond those effects immediately obvious and possible means whereby these effects may be mitigated.

With regard to construction activities, for example, the following activities have the given ecologically oriented ramifications and mitigations:

Site Preparation, Clearing and Grubbing — Ramifications: This involves total destruction of terrestrial ecosystems at the site and probable impact on nearby running water due to increased erosion from the construction site. Stumping is important only if activities are carried on beyond cleared areas.

Mitigations: Clearing and grubbing activities should be restricted to as small an area as possible while still permitting needed construction to limit terrestrial damage. Often trees and other vegetation can be left standing within the construction to limit terrestrial damage. Often trees and other vegetation can be left standing within the construction site with little loss of time. Every effort should be made to leave as wide a band of vegetation between construction site clearing and local bodies of water (particularly streams) as possible. The specific choice of site may be critical here.

***Demolition*—Ramifications: The imact of the factor depends on the size of the project. Large-scale demolition of any material will have a heavy effect on the immediate environment; small-scale activities will have little effect. Demolition carried out entirely within a nonnatural area would not normally be important in its ecological implications.**

Mitigations: Where possible, demolition should be done in stages to produce the least possible disturbance of the environment.

***Excavation, Grading — Ramifications:* Grading may expose soil to erosion with harmful effect on aquatic ecosystems as silt-laden water washes into bodies of water. This may extend for miles downstream, adversely affecting fishing and hatchery operations.**

***Mitigation:* Mitigation of erosion and of corresponding drop in water quality is best obtained by leaving an undisturbed belt of vegetation between grading activities and all bodies of water.**

***Lumber Construction, Pest and Insect Protection* — Ramifications: Insecticides used to protect wood products may contaminate local environments if excess quantities are used.**

***Mitigations:* Concentrations and volume of pesticides used should be evaluated to prevent use of excess quantities which can endanger desirable animals either directly or indirectly. Disposal of empty containers and excess chemicals should follow EPA guidelines, and should never be emptied into sewer systems or bodies of water.**

Health Science.

Introductory Commentary.

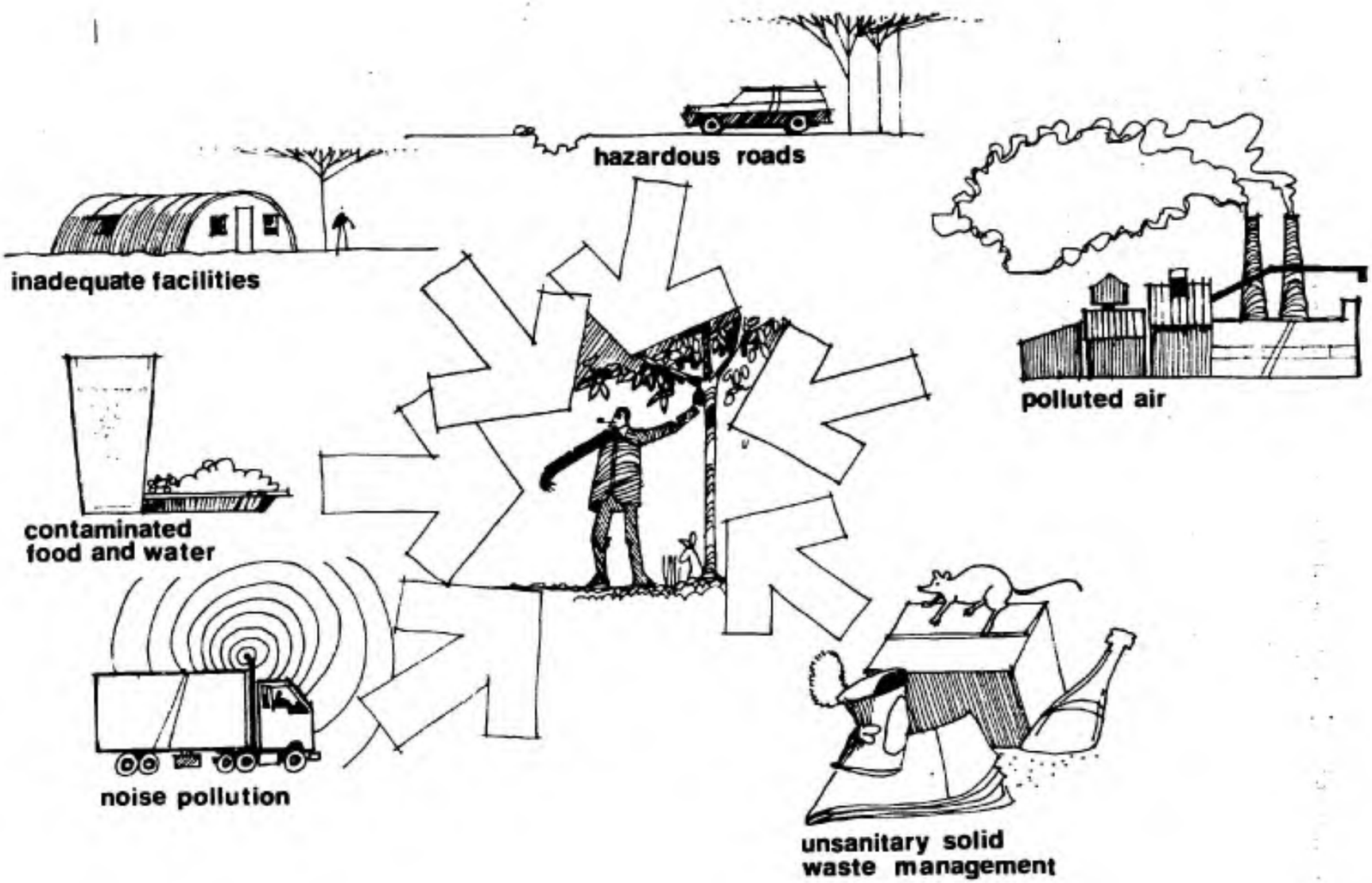
Better a poor man healthy and fit
than a rich man tormented in body.
Health and strength are better than any gold,
a robust body than untold wealth
no riches can outweigh bodily health.
no enjoyment surpass a cheerful heart.
Better death than a wretched life,
and everlasting rest than chronic illness.

Taken from *The Jerusalem Bible* (Ecclesiasticus 30: 14-17)

Man's health will be more and more adversely affected if he continues to be exposed to a "life support system" that is increasingly burdened with substances, activities, and interactions that threaten his good health. For example, "John Q. Army Laboratory Technician" has been working all day in the presence of noise from a continuously operating vacuum pump and continuously running water from a siphon he has been using. He has been exposed to a poorly lit laboratory, ether from the chemical reaction his colleague has been performing, and pressure from his supervisor to complete his present task in an almost impossible time frame. The combined mental and physiological effects of these "stressors" has given John a headache, a mild upset stomach with nausea, blurred vision, and has disrupted his ability to think clearly. In his urgency and confusion, John accidentally discards a large volume of hazardous radioactive waste into the public sewage system. Each one of us is representative of a "John Q." more often than we would like to imagine, both on and off the job.

The above example also serves to illustrate the interaction of human health with other technical specialties. John's health was adversely impacted by noise, air quality, and pressure from his supervisor. His physical and mental state in turn had an adverse impact on surface water quality which in turn may have had an adverse impact on the health of others. Multiplying John's impact on surface water many times over, and considering the "degrading cycle" which develops in the absence of corrective measures, one can quickly see why gigantic environmental problems exist throughout the nation and the world.

Elements (impactors) which result directly or indirectly from Army activities, and which by definition may have a negative physical or mental effect



HUMAN HEALTH IMPACTORS

on the health and well-being of man, can be classified into three general categories: (1) chemical, (2) biological, and (3) physical elements. Their presence or absence may have a negative effect on man's health. Examples of those elements whose presence would possibly be injurious to man would be man's direct exposure to high concentrations of chemicals like carbon monoxide, pathogenic and parasitic organisms such as those causing venereal disease or the common cold, or direct exposure to physical elements like ionizing radiation. Examples of those elements whose absence could be injurious to man's health could be the absence of bacteria for the treatment of sewage, the lack of necessary body chemicals such as water and minerals, and insufficient physical elements which are needed to provide man protection from inclement weather.

Specific examples of direct human health impacts would be dust inhalation generated from mining and construction activities, and inhalation of fumes from asphalt paving and automobile engine exhaust.

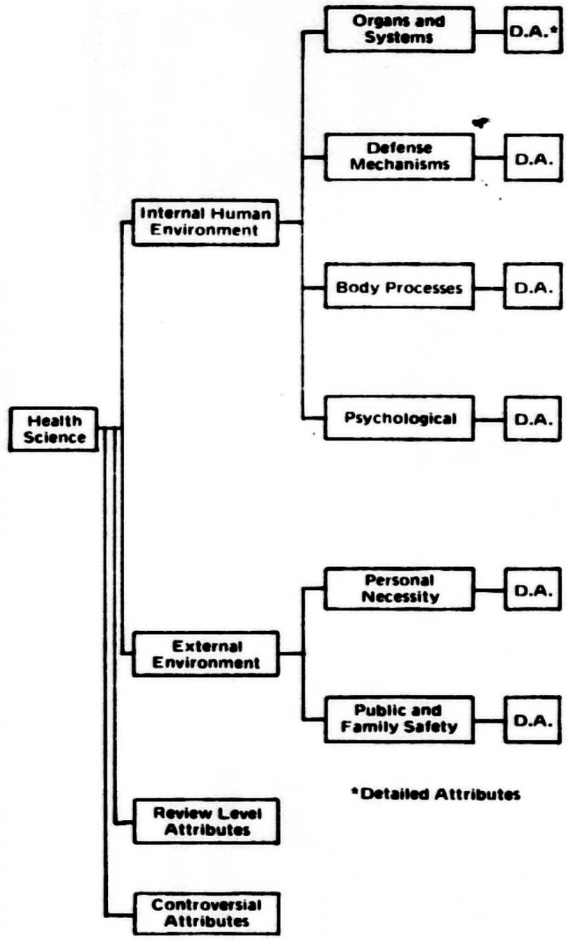


Figure 13. Attribute Hierarchy for Health Science

The human health attributes are broken into two broad categories (Figure 13): (1) the internal human environment and (2) the external human environment. The internal environment includes those areas of physical and mental health such as organs, systems, and behavior. Attributes of the external environment include those aspects which are absolute necessities to maintaining good physical and mental health, such as nutritional supply, shelter, and clothing. Also, those areas dealing with man's public and personal safety such as in transportation, home, work, and recreation are included as attributes of the external environment.

The following are examples of human health attributes, and how they are impacted by Army-related activities:

The *body systems* include organs and tissues involved in respiration, circulation, excretion, reproduction, nervous response, digestion, and support. Activities which have an adverse impact on the organs and tissues involved with circulation, for example, would affect that system. Carbon monoxide poisoning, which results from inhalation of automobile exhaust or gas from a defective stove or heater, impacts the circulatory system because its affinity for the oxygen-carrying tissue (red blood cells) is greater than that of oxygen. This impact affects the rest of the body's tissues and organs because in this condition they lack an adequate oxygen supply. An individual will therefore succumb due to asphyxia unless he is returned to an atmosphere with a low carbon monoxide concentration. The fact that people may be seriously impaired psychologically by carbon monoxide without experiencing any awareness of poisoning is insidious. A bulldozer operator experiencing apathy, headache, and spatial disorientation from subacute carbon monoxide exposures may accidentally commit a tragic accident by burying several men or upsetting the machine on himself.

Defense mechanisms of the body such as skin covering, special cells, or biochemical reaction mechanisms, are very important in the prevention of disease because they exclude, neutralize, absorb or eliminate substances that would otherwise be harmful to the body. Damage to and alteration of these mechanisms may expose an individual to serious infection or damage the body through their uncontrolled activity. Construction workers who experience injury to the skin from burns by touching a hot exhaust pipe, for example, are more vulnerable to the entry of disease-causing organisms through the burn. Chronic radiation exposure causes alteration in the white blood cell-forming organs, often causing the usually fatal disease leukemia. White blood cells normally control the spread of foreign matter which enters the body. In leukemia (an uncontrolled overgrowth of white blood cells) the body channels excessive energy to produce white blood cells at the expense of other bodily functions necessary for good health.

The *body processes* include growth, development, metabolism, and stability. Interaction of various body organs and tissues perform these processes. Therefore, impact upon any one of a number of organs or tissues could alter a body process such as growth. The most serious growth-affecting problem is cancer, which is an uncontrolled, destructive growth of some body tissue. Many chemical, biological, and physical factors or combination of factors have been found to initiate or promote cancer. A construction worker involved in demolition might be incinerating waste material. The resultant smoke and fumes could expose his skin and lungs to the carcinogen (cancer-causing agent) 3,4 - benzopyrene.

Behavior can be greatly influenced by chemical and physical elements, situations, and confrontations which directly cause psychological stress.[22] Aberrant and antisocial behavior leading to conflict, crime, and accidents may be the result, especially where compounded chronic psychological stress is involved. A new recruit may be exposed to a combination of psychological stressors. He may be exposed to racial and ethnic conflict, exposed to a new and regimented environment, put through strenuous physical exercises with which he is not accustomed, and exposed to noise from guns, artillery, and men in his barracks.

These stressors may cause him to lose sleep and become tense. Even though this combination of factors may have little effect on others, it may cause him to rebel, quarrel, run away, or cause a serious accident with a vehicle or weapon.

The human body requires that specific *external elements* be in constant supply in order for it to function properly. These include protection from adverse climatic conditions and intake of a well-balanced nutritional supply. It is difficult to imagine how or why these requirements are missing in the lives of Americans today. Yet, it is not uncommon for physicians to find nutritional problems in those with sufficient means to provide the best of foods. Other Americans still perish needlessly or exist in poor health because they lack these basic physical requirements. Due to ignorance and negligence, it is possible that nutritional problems exist in numerous military families, although Army-prescribed diets are designed to be nutritionally balanced. Inadequate identification of casual factors related to transmittal of upper respiratory disease in new recruits is still a problem. Overexposure to adverse climatic conditions may still be a problem in special maneuvers and field training exercises.

Public and family safety is the last group of health science attributes listed. They include individual safety at work, home, and play, and public safety in transportation, facilities, clean air, clean water, and uncontaminated nutritional supplies. Without appropriate safety measures tragic epidemics and accidents can occur. A great public risk is involved in the production, storage, transport, and disposal of highly infective biological warfare weapons and highly poisonous chemicals such as nerve gases. Vehicles unsafely made in production or faulty in maintenance cause unnecessary risk to the lives of troops as well as the public who use the same roadways.

[22] Mortimer H. Appley and Richard Trumbull, *Psychological Stress* Appleton-Century Crofts, 1967).

Examples of Typical Detailed Attributes.

GASEOUS EXCHANGE IN THE LUNGS

A.

Exchange of oxygen, carbon dioxide, and other gases between the air sacs of the lung and the blood.

B.

Man is more susceptible to lung puncture or collapse from activities involving transportation, heavy equipment, machine shops, and blasting. Tuberculosis and some forms of pneumonia are contageous diseases that can be transmitted through personal contact (i.e., kissing) and possibly through sneezing, coughing, and utensils that are often put into the mouth. Pneumonia (filling of the air sacs of the lung with fluid) often results from another disease, usually respiratory, which may have been neglected, thereby weakening the body and making it susceptible to pneumonia-causing organisms. Emphysema may result from chronic obstruction of lung airways through infection, irritation, or physical blockage. Incidents of emphysema have also been linked to people who smoke heavily and possibly to those who live in areas of severe air pollution. Silicosis, pneumoconiosis and related diseases which frequently occur in miners, stone cutters, and stone grinders, are caused by chronic exposure to a variety of particulates like coal dust and silica.[23]

C.

Even though plentiful oxygen may reach the air sacs of the lungs, disorders such as emphysema, tuberculosis, blast injury, or mechanical injury to the lung destroy tissue important to gas exchange, and permanently decrease the amount of tissue available for oxygen exchange to take place.[24] Diseases such as pneumonia, which fill the air sacs with fluid, temporarily prevent air from coming in contact with gas exchange tissue. Diseases such as chronic heart failure, pneumonia, silicosis, and tuberculosis cause a permanent increase in thickness in the tissue across which gas exchange occurs, thereby decreasing the efficiency of exchange.[25]

D.

Any permanent lung damage or chronic infection of lung tissue taxes the heart and leads to chronic or acute heart failure. Such an impairment, if not fatal may lead to poor job productivity and lost time due to illness; thereby resulting in a substantial economic loss to the employer.

BODY SYSTEM HEALTH SCIENCE ATTRIBUTE

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[23] W. A. Douglas Anderson, *Synopsis of Pathology*, 6th Edition (Mosby, 1964).
[24] Arthur C. Guyton, *Textbook of Medical Physiology*, 4th Edition (W. B. Saunders Co., 1971).
[25] W. A. Douglas Anderson, *Synopsis of Pathology*.

VISION

A.

The act or power of seeing with the eye.

B. and C.

Vision may be impaired from the following kinds of activities:

1. Exposure to direct sources of very bright or ultravoilet light such as in welding, using therapeutic lamps, exposure to environments where sunlight is reflected from snow, from observing eclipses of the sun with the naked eye, and working in laboratories and industries where untraviolet lamps are employed to observe fluorescence of chemicals. Eye exposure to infrared light from heat or drying lamps can also cause eye damage.[26]

2. Occupations where there is exposure to suspensions of abrasive dust, fine hairs, and other particulates.

3. Explosions.

4. Activities where sharp pointed or bladed instruments are in active use.

5. A great number of chemical vapors which are used in industrial and laboratory processes. There are chemicals (i.e., wood/methyl alcohol) that when taken internally can cause permanent or temporary blindness.

7. Activities producing hysteria and associated mental problems.

8. Veneral diseases such as gonorrhea and syphilis contracted through sexual intercourse.[27]

9. Microwave radiation.

10. X-ray or gamma radiation can cause cataracts (opaque corneal tissues).

D.

The degree of vision impairment is dependent upon the degree of physical injury, chemical exposure, or exposure to biological infection. The eye has a very limited capacity for repairing itself; therefore damage to vision or permanent blindness may result from such exposures. Poor vision not only limits the kind of work that one can perform but also increases the chance of injury or accident both on and off the job.

BODY SYSTEM HEALTH SCIENCE ATTRIBUTE

[26] Frank A. Patty, *Industrial Hygiene and Toxicology*, 2d Edition, Vol. 1 and 2 (Interscience Publishers, Inc., 1958).
[27] W. A. Douglas Anderson, *Synopsis of Pathology*, 6th Edition (Mosby, 1964).

BEHAVIOR

A.

The way a person acts in response to an internally or externally applied physical, chemical, biological or other stimulus.

B and C.

Activities that cause psychological and/or psychophysiological stress lead to aberrant behavior. A large number and variety of stimulators are believed to cause stress to some degree in experimental animals and man. Activities which include the following factors might cause stress in man:

1. **Weightlessness**
2. **Acceleration**
3. **High and low pressure**
4. **Abnormal atmospheric pressure and concentration composition (i.e., relative concentrations of CO_2, N_2, and 0_2)**
5. **Extreme temperature variation**
6. **Sleep deprivation - fatigue**
7. **Pain exposure**
8. **Noise, vibration**
9. **Threat to "life and limb"**
10. **Threat to status/self esteem**
11. **Sustained performance of a task**
12. **Exposure to phobic agents (e.g., to enclosures for a claustrophobe).**

Construction activities such as demolition, stone cutting, and earth moving would expose workers to numbers 4, 8, 9 and possibly 5, 6, and 11. Mission change activities such as alteration of job tasks or job qualifications might impact number 10 and indirectly affect numbers 6 and 9.

D.

Maladaptation to stress is believed to play a role in diseases of the heart and blood vessels, diseases of the kidney, convulsion (eclampsia), rheumatism and rheumatoid arthritis, inflammatory diseases of the skin and eyes, infections, allergy and hypersensitivity, nervous and mental diseases, sexual derangements, digestive and metabolic diseases, and cancer. Some of these diseases in turn can have a profound effect on work efficiency, accident frequency, satisfactory social interaction, and generally the health of the human and nonhuman environment.

PSYCHOLOGICAL HEALTH SCIENCE ATTRIBUTE

NUTRITIONAL REQUIREMENTS

A.

Those chemical requirements, such as vitamins, minerals, proteins, fats, carbohydrates, and water, which are absolutely necessary for good health.

B.

In general, the Army supplies its dining facilities with well-balanced and adequate foods. However, physicians are finding that many Americans with sufficient means to supply a proper diet are suffering from malnutrition. The cliche that "one can lead a horse to water but one cannot make him drink" is therefore worth restating. Insufficient education, poor attitudes, and overconsumption of nutritionally poor food are thought to be partial causes of the nutrition problem. Army families and even Army mess users could therefore conceivably suffer malnutrition in refusing to consume the well-balanced diet provided for them.

C.

Malnutrition is caused by continual consumption of less than the minimum daily requirement of part of the essential elements listed above. Eating a well-balanced diet of meat and fish, vegetables, starches and dairy products which have not had their nutritional value removed in preparation and processing provide more than the minimum daily requirement of essential nutrients. Overnutrition is also a health problem. Not only does general overeating lead to overweight and its associated problems, but also excesses of essential minerals and vitamins can be toxic to varying degrees.

D.

Consumption of an adequate nutritional supply is essential to a continued mentally and physically healthy society.

PERSONAL NECESSITY HEALTH SCIENCE ATTRIBUTE

TRANSPORTATION SAFETY

A.

Refers to the safe design, production and maintenance of air, rail, road and water vehicles, and transportation facilities.

B.

All activities involving the transportation of Army personnel and their families, and heavy equipment and supplies, has potential impact on public safety.

C.

The following elements increase public health transportation hazards:

a. Exhausted, ailing, or intoxicated vehicle operators.

b. Poor original design of vehicles and roadways.

c. Poorly maintained and inspected vehicles and roadways.

d. Insufficient or faulty guidance systems, signs, and signals.

e. Distractions (i.e., billboard advertisements, truck and radio noise, and bright lights).

f. Poor weather conditions (i.e., wind, rain, ice and snow).

D.

Thousands perish or are made temporarily or permanently debilitated each year due to vehicular accidents. Such accidents lead to property loss, additional welfare cases, and a possible increase in crime and antisocial behavior.

PUBLIC AND FAMILY SAFETY
HEALTH SCIENCE ATTRIBUTE

Review Level Attributes. The human body organs which provide man's *sensory* input from the senses, his external environment, are vulnerable to some of the impacts from Army activities. Because of their functions, they are directly exposed to the external environment (that environment surrounding the human body). Because of their close proximity with this environment, and because man is generally more aware of their functional disorders than those of any other body organ, he probably does more to safeguard his sense organs than any other organ. However, with the exception of providing for safeguards against the most obvious physical hazards, such as wearing special goggles when working with an acetylene flame, he is only beginning to provide safety measures against the chronic, subtle impactors resulting from his activities.

The most obvious Army activities which affect senses include nearly all field work, such as construction and field training, and in-house activities such as laboratory work, machinist work, and other activities involving the handling of physically or chemically hazardous materials. Less obvious activities would include those involving exposure to noise levels that are not stressful enough to take immediate corrective action, but over a long period of time may cause hearing loss. Another example would be working with ultraviolet light which causes no immediate discomfort when observed directly, but can cause vision loss after chronic exposures.

Although the *internal organs* are not in direct contact with the external environment, they may be directly or indirectly affected in many ways as a result of activities in the external environment. They may be exposed via the blood stream to organisms or poisons introduced at the cut surface of the skin, from toxin absorption in the gut, or emissions of toxins from another organ malfunctioning because of an external environmental impact. There are many biological organisms, toxic chemicals, physical factors, as well as mental stressors, which may have a profound impact on internal organs. Perhaps the most susceptible organ exposed to the impacts of external activities is the liver. Immediately after the absorption of toxins in the gut, the liver is the first major internal organ exposed to the toxins. Activities impacting the internal organs generally have one or both of the following characteristics:

1. They provide a great potential for entry of an impactor into the body, such as potential for trauma to skin, contaminating respiratory air, or contaminating food and water; and

2. Associated with the activity must be the chemical, biological, or physical substance whose presence or absence is capable of having a toxic effect on these internal organs.

The most obvious Army activities having these characteristics are those in the laboratory or shop, and field activities involving plentiful physical activity, equipment and materials handling, and extreme physical conditions such as loud noise emissions which might have an indirect adverse affect on internal organ functions.

Herein defined, the *body processes* include all of the major functions of the body. They are generally performed by a combination of organs and tissues. These processes include respiration, circulation, excretion, digestion, elimination, support, growth, development, neural functions, reproduction, metabolism, and stability. It is in this category that some of the indirect physiological effects of impacts of Army activities will be considered.

As with internal organs, body processes are most affected by those activities which provide impactors whose physical characteristics or source enable them easy access into the body and would include physical, chemical, biological, and situational elements. Both X and gamma radiation exemplify a physical element which penetrates the human body surface with ease, thereby impacting susceptible tissue such as the digestive tract and bone marrow causing digestive and circulatory disorders, respectively. Examples of chemical elements that easily penetrate the body surface at the skin, lungs, and/or gut include carbon monoxide, barbiturates, mercuric chloride, methy alcohol, aniline, cresol, phenol, tetraethyl lead, and other hazardous liquid aromatic nitro and amino compounds.[28,29] Biological organisms enter the body through cuts, body. Micro-organisms enter the body through cuts, burns, and other injuries; ingested food and water; and inspired air. In addition to toxins from micro-organisms, poisons from snakes, spiders, sea animals, and plants can affect mans' health. Specific examples would include the blowfish, tetanus,

[28] *Fire Protection Guide on Hazardous Materials*, 4th Edition, National Fire Protection Agency, No. SPP-1A (NFPA, 1972).

[29] E. R. Plunett, *Handbook of Industrial Toxicology* (Chemical Publishing Co., 1966).

botulinus, and toadstools (poisonous mushrooms).[30] Those organisms and toxins that enter in contaminated food can often be eliminated through sufficient cooking. Mental stress resulting from the demands and tensions of "the fast and competitive" American way of life may be indirectly related to circulatory disorders such as heart failures and disorders involving nervous and digestive functions.

The physical and chemical impactors would arise mainly from Army activities related to various industrial processes, laboratory work, and field activities involving the manipulation and operation of heavy machines and equipment. Biological impactors would more likely be found in remote field activities and those activities involving or near unsanitary conditions such as garbage dumps or raw sewage.

This area, of *mental health* study includes the effects of Army activities on such psychological characteristics as emotion, motivation, the learning process, general behavior, and psychological needs such as freedom, space, privacy, societal acceptance, utility in society, and purpose to life.[31] Activities affecting mental health would have the characteristics of providing the chemical, biological, and/or physical material, or human interaction, which would serve as a psychological stressor. These stressors might affect emotional stability, ability to be motivated, or ability to think sharply and clearly in emergency situations which demand immediate and prompt specific reactions.

Impactors may cause mental effects ranging from direct physical damage to the brain tissue to temporary irritability, depending on the nature and degree of exposure to the impactor. Specific impactors that have been related in some way with the temporary or permanent degradation of mental health include lead, mercury, carbon monoxide, some insecticides, noise, inadequate housing, and possibly the lack of recreation and mental stimulation.[32]

The mental health consequences of lead poisoning are so tragically prevalent that they have been studied extensively. The overwhelming majority of known victims are children who have been exposed to flaking lead-based paint on home interiors.[33] Occupational exposures occur in activities including mining, smelting, milling, casting, metallizing, and the handling of pigments, insecticides, batteries, solders, and alloys. Specific Army-related activities which could afford exposures to lead would be the production and handling of ammunition, and servicing or continual operation of automobiles, especially operation in heavy traffic.

Basic individual needs include the physical and chemical essentials that all individuals require, as well as those necessitites resulting from the society and culture in which they live.

Basically, the Army more than adequately supplies troops with personal necessities. Married servicemen that have families to feed, clothe, and shelter may, however, be in a different situation. It is not uncommon for physicians to find nutritional problems among those with sufficient means to provide the best of foods. This problem may be due to negligence, lack of knowledge regarding nutrition, and the production and marketing of many nutritionally poor foods by the food industry. Many breakfast cereals, for example, have been accused of being nutritionally poor. Numerous American residences, including Army barracks and family housing, could be designed incorporating more adequate health and safety design criteria. Poor heat circulation in buildings creates "cold spots" and "hot spots." Heating without humidification creates extremely dry and dusty interior air which dehydrates air passages in the nose and throat. These indoor air quality problems may be related to increased susceptibility to upper respiratory infection and consequent medical bills and loss of man-hours at the expense or the Army.

Many of the training activities involving hazardous equipment such as weapons may be a greater risk than is "necessary" to those involved. Unusual outdoor maneuvers involving extensive exposure to harsh climatic conditions may not be an "absolute necessity."

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[30] Findlay E. Russell, and Paul R. Saunders. *Animal Toxins* (Pergamon Press, 1967).

[31] Mortimer H. Appley, and Richard Trumbull. *Psychological Stress* (Appleton-Century-Crofts, 1967).

[32] *Pollution: Its Impact on Mental Health*. Department of Health, Education, and Welfare Publication No. 9135 (U.S. Department of HEW, 1972).

[33] *Pollution: Its Impact on Mental Health*.

Basic group needs such as sanitation, food and water supply, recreation, and safety, are important factors. Very few individuals in today's American society can exist alone. Technology has truly made each man "his brother's keeper." In large urban centers man needs adequate sanitation systems to prevent epidemics of disease, as well as an accessible and sufficient food and potable water supply. He needs to have the waters of surrounding polluted rivers purified and made suitable for drinking and recreational activities. He needs to have the necessary ways and means to supply his dependents with at least the basic necessities. Man needs to be free from the threats of smog, power shortages and failures, transportation disasters, and high-rise facility fires that have in the past taken the lives of so many.

Many Army activities or Army-induced activities contribute to making an unhealthy "life support system," or create public safety hazards with potentially insidious consequences. Many industrial processes, such as steel production, specifically operating to generate material to be utilized by the Army, still pollute community air and water. Great risk is incurred to large numbers of people, directly or indirectly, in the production, storage, and transportation of highly toxic and concentrated materials such as defoliants and chemical, biological, and nuclear warfare weapons.

Controversial Attributes. Several examples of potentially controversial human health attributes are listed below. They are presented as broad-scope representatives to assist the user in predicting and avoiding controversial issues related to human health. The examples presented here, as well as others that could be listed, possess factors in common which normally potentiate controversy or increase its severity. The following are some of these factors and may be used in aiding assessment of a potentially controversial activity which impacts on human health:

1. The number and identity of persons involved with or affected by the activity;
2. The legitimacy of the activity and the resulting controversy;
3. Past occurence and repeatability of the activity; and
4. Corrective measures taken to eliminate the aspects of the activity that make it controversial.

In today's highly scientific and technological society man is discovering that many new compounds and chemicals which he has produced and used are carcinogens; they either cause or can be related to cancer in man or in experimental animals. He is also finding that some of the substances that he used to produce as consumables have a similar effect. Two points must be considered:

1. This attribute is generally not controversial unless man is unknowingly led or knowingly forced into exposure to carcinogens.

2. If an agent has been shown to cause cancer in an experimental animal but not in man, the potential of the chemical as a human carcinogen is controversial.

For example, cyclamates (dietary sugar substitutes) have been found to cause cancer in experimental animals when administered in high concentrations and large amounts. However, the significance of the animal experiments for the human consumption of cyclamates in diabetic foods is controversial and hotly debated.

Presently, the law (Delaney clause) states that no chemical may be intentionally added to food if it has been shown, through an appropriate route of administration in a scientifically valid experiment, to produce cancer in man or animals.

Those activities which involve the handling of carcinogens or elements known to potentiate cancer indirectly are many. The following will serve as the more important examples:

1. 3,4 benzopyrene and other polycyclic aromatics—originally found in coal tar, but produced in activities involving combustion, such as smoking, power production, and charcoal grilling.
2. Aromatic amines and amino azo dyes—most often found in people working chronically with the dye such as in dye industries.
3. Ionizing radiation—found in the laboratory, nuclear power generation, medical practice and industry (i.e., determining metal thickness, etc.).
4. Nitrosamines
5. Ultraviolet radiation
6. Other carcinogens—heavy metals, aflotoxins, saffarol, alkylating agents (nitrogen mustard), and viruses such as those causing upper respiratory disease (adenoviruses - a disease problem among new recruits) are known to be cancer related at least in laboratory animals.[34]

[34] W. A. Douglas Anderson, *Synopsis of Pathology*, 6th Edition (Mosby, 1964).

There is much discussion as to whether food and water additives, whether intentional or unintentional, are health hazards. In some cases it may be only a matter of opinion. This is a controversial attribute when one is forced or unknowingly led to consume a potentially harmful food or water additive or when illness of large numbers has been linked to food poisoning. The Army feeds large numbers of troops daily and therefore is highly susceptible to this particular controversial attribute. Monosodium glutamate added to food mainly to enhance its flavor, while fluoridation of water supplies aids in building strong, decay-resistant teeth. However, there is some argument as to whether these compounds consumed chronically over long time periods will cause some physiologically damage.

With the exception of GRAS chemicals (generally recognized as safe, i.e., salt) and certain other specified chemicals, all other chemicals intentionally added to food intended for human use must undergo rigorous testing before they are released for consumption. The previously accepted chemicals are also subject to toxicological review if they become suspect for any one of a number of reasons.

Unintentional food additives are introduced in production, storage, distribution, and handling of foods. They would include pesticide and herbicide residues, oil drippings from production machinery, chemicals leached from storage containers, and a variety of chemicals and biologicals introduced during the careless preparation and serving of food.

Using *man as an experimental subject* in any situation should be approached cautiously. Having a man's verbal or written consent is generally not adequate. Many universities have special committees of experts organized to evaluate experimental projects which utilize human beings. They determine what harmful consequences there might be in association with the use of human subjects, and all details of the experiment are completely documented and reviewed beforehand. Without such measures, the subject can file a successful law suit for damages incurred during the experiment.

When a part of one's ability to communicate with his surroundings is permanently removed, he is most unhappy. The loss of senses or the inability to transport oneself because of loss of limbs requires considerable adjustment in anyone's life. Such circumstances generate fear, resentment, and hostility in the victim as well as his peers. It is this kind of disability which attracts considerable sympathy from others. Public sentiment can be a powerful political force.

Construction activities such as blasting and handling of materials that are physically or chemically hazardous to the senses merit consideration with respect to this attribute.

The number of victims and degree of carelessness greatly determine the level of controversy.

Psychological stressors are chemical and physical elements, situations, and confrontations that cause mental tension and strain. They may be physical situations such as traffic congestion, noise, intense air pollution, or inadequate working and living facilities. They may be attitudes to which one is either asked to comply, or is confronted with in others around him, but attitudes in which he does not believe; examples are various kinds of discrimination, conformity, and combat training. They may also come in the form of some activity which an individual deems useless, regardless of its real value, such as "red tape" activities. They may be seemingly insoluble problems of life such as lack of purpose to life or even facing death. Conflict and controversy can also be psychological stressors. Therefore stress is interwoven with all other controversial attributes. These are but a few examples of psychological stressors.

Stress is important because it breeds confusion, anxiety, resentment, lack of confidence, and plays a role in a number of diseases and physiological disorders which detract from one's ability to concentrate, be alert, and perform daily tasks at work and at home.[35] This increases the probability for inefficiency, mistakes, and accidents.

The recognizable presence of *health hazards* has become more controversial through time because the general public is more informed and aware today than ever before. If a significant number of people conclude that lives are endangered with or without justification, controversy will likely develop.

The Army should consider this attribute in relation to both the civilian and military communities

[35] Mortimer H. Appley and Richard Trumbull, *Psychological Stress* (Appleton-Century Crofts, 1967).

In the military community, potentially controversial situations include training activities that breed unusually high numbers of accidents, and facilities and equipment that are recognizably hazardous. The civilian community would be involved in the controversy when the hazards of the military activity extends into the surrounding community. Examples of such activities could be chronic drinking (and driving while under the influence of alcohol) by personnel in uniform; production, storage, transport, and disposal of hazardous materials like explosives and chemical warfare weapons; and excessive air pollution associated with industries in which a majority of the products are for military use.

Drugs and narcotics are here defined as chemical compounds which affect the behavior of the user by causing stimulation, depression, and/or hallucination. Narcotics relieve pain, induce sleep, and generally have a soothing, lulling, and dulling effect on the user. The most frequently used drugs include alcohol, marijuana, barbiturates, and LSD (lysergic acid diethylamide). The hard, physically addicting narcotics include morphine, heroin, cocaine, and codeine.

The Army should consider the following as controversial issues associated with drugs and narcotics:

1. Could moderate use of drugs such as marijuana become harmful or addicting to the user? If not physically addicting, will they cause psychological dependence?

2. Is the moderate drug user a potential hazard or burden on the rest of the public? Will he cause more traffic accidents, commit more crimes, or be more likely to go on welfare?

3. Will the use of "soft drugs" such as marijuana lead to the use of "hard drugs" like heroin?

4. Should "soft drugs" be legalized or should the penalty for use be minimized?

5. What constitutes an addicted user? Is a serviceman home from Vietnam with a history of taking drugs a drug addict? How should past drug records be handled with reference to the user's future?

These issues have become more serious and more openly discussed in an increasingly more permissive society. Regardless of what stand the Army takes on these issues, criticism will likely result.

Selected Ramification Remarks and Mitigation Statements.

The following are selected ramifications from "subsurface excavation," construction functional area. The chronic vibration produced in operating heavy equipment and vibrating tools such as the jackhammer may cause psychological stress and/or eventual dislocation of organs such as the kidney and bladder, therefore every effort should be made to eliminate these vibrations before they reach the body.

The general behavior of an individual may be affected by the combinations of stressors encountered in many activities. In subsurface excavation, for example, loud noise, poor or intermittent diverse lighting, dampness, and the (understandably) generally poor working conditions may interfere with mental processes such as attention span and ability to think clearly, thereby making one a hazard to others. Maladjusted individuals should be identified and relocated to a position to which they can adjust.

The chronic effects of many environmental elements to which man is exposed have not yet been determined, therefore unnecessary exposure to any substance, regardless of how harmless it appears to be, is unwise.

The following is a list of selected mitigation statements from "subsurface excavation," construction functional area.

1. *Eye protection* should be employed anytime one is working in an atmosphere of suspended particulates and vapors, fast moving bits of matter as produced in cutting, drilling, and lossening stone, or in an atmosphere of ultraviolet, infrared, and other damaging radiations. A device should be chosen that will minimally restrict vision, yet provide complete seal around the eyes. Special shatterproof materials should be used in the lenses.[36]

2. *Protective headgear* should be worn during activities involving the movement of sharp and heavy materials, when working underground and near or under aboveground activities, and in any general area of heavy construction. The gear should fit so that it cannot be removed easily by accident, should

[36] William Handley, *Industrial Safety Handbook* (Berkshire England: McGraw-Hill Publishing Co. Ltd., 1969).

be of the best shock-absorbing quality, and fluorescent or luminescent so that it can be seen easily in all lighting conditions. It should also provide adequate ventilation to discourage removal because of excessive perspiration. It should be designed so that it does not greatly restrict vision or hearing.

When exposed to highly toxic vapors, especially those that are readily absorbed through the skin, the entire head should be protected from the atmosphere by apparel that completely seals the body from the external environment.

3. *Respiratory protection* should be employed in the presence of finely suspended particulates, vapors, disease-causing organisms, or in an atmosphere lacking oxygen. Respiratory hazards are increased in confined areas or in areas of stagnant air such as might be found in mines, quarries or man-made facilities. The filters in such gear should be effective in filtering out the size and kind of materials most commonly encountered, and should be changed and inspected regularly. The gear should be as comfortable as possible and should fit properly. In confined areas and other areas of potential oxygen depletion or cutoff, the gear should provide supplemental air as well as filtration.[37]

4. *Safety uniforms* should be utilized in the presence of hot objects or particles like those encountered in welding or working with hot asphalt. They should also be worn to prevent skin contact of caustic, corrosive, and highly abrasive chemical compounds. The uniforms may vary from a slip-on cape or overcoat for temporary work, to an entire tailored uniform for those who are exposed daily. This apparel should be specifically cleaned, decontaminated, or discarded more regularly than normal clothing, and replacements should be made readily available. They should be light, comfortable, and ventilated whenever possible to prevent restricted movement and excessive perspiration. The popular use of disposables should be kept to a minimum whenever possible to prevent accumulation of solid waste and depletion of nonrenewable resources.[38]

5. *Safety gloves* should be utilized in the presence of hot objects or particles as is encountered in welding or working with hot asphalt. They should also be worn to prevent skin contact of caustic, corrosive, and highly abrasive chemical compounds. They should be as light and flexible as possible so as not to highly restrict grasping ability or finger manipulations. They should be washed, cleaned, decontaminated, or discarded with care. The popular use of disposables should be kept to a minimum whenever possible to prevent accumulation of solid waste and depletion of nonrenewable resources.

6. *Safety boots and shoes* with steel toes, strong arches, and sufficient ankle support should be utilized in all heavy construction work or in activities where crushing, cutting, or bruising may occur from the manipulation of heavy equipment and tools. The footwear should be as light and comfortable as possible so that movement is not restricted and perspiration is kept to a minimum. The sole should be made of material that will prevent loss of footing.[39]

7. A *complete body seal* is necessary only when one must work in the presence of biological or chemical elements which are not only highly toxic but enter the body easily by way of the skin. The clothing should be tested before use and carefully monitored and decontaminated after use. The seal should be as light as possible to allow maximum body movement and manipulations.

8. *Education* and testing of the participant in the following areas is perhaps the most important mitigation technique possible:

a. The nature of the hazardous activity being performed.

b. The physical and chemical properties of all toxic materials handled including products, by-products, and chemical wastes generated by the activity.

c. The various mitigation techniques available for controlling the hazard, and complete information regarding their principles, use, and handling.

d. The steps to be taken in case of an emergency.[40]

9. *Strict enforcement* of rules and regulations regarding hazardous activities and materials

[37] *Safety-General Safety Requirements*, Engineering Manual No. EM-385-1-1 (Department of the Army, 1967).

[38] William Handley, *Industrial Safety Handbook* (Berkshire England: McGraw-Hill Publishing Co. Ltd., 1969).

[39] William Handley, *Industrial Safety Handbook*

[40] Handley.

handling is of utmost importance. All of the education, safety equipment, and effort to preserve human health will be useless if the employment of safety factors is disregarded. The penalty for not following through should be severe enough at both the worker and supervisory levels to more than discourage breaking of the rules.

Air Quality.

Introductory Commentary. In assessing the primary resources that are needed to sustain life, one must consider air as being one of the most, if not *the* most, critical resource. Without air, life on this planet could not exist. What makes air quality particularly vulnerable is the fact that air, unlike water or other wastes, cannot be reprocessed practically at some central location and subsequently distributed for use. If the air becomes poisonous, the only alternative to sustain life is for each individual to wear some sort of life support system. This is clearly unworkable and economically infeasible. When emissions and unfavorable climatic conditions interact to create undesirable air quality, the atmospheric environment may begin to exert adverse effects on man and his surroundings. Air may be replenished through photosynthetic processes and cleansed through precipitation, but these natural processes are limited in their effectiveness. Hence great care must be exercised in assessing and maintaining the quality of our air resources. It therefore seems self-evident that the protection of our air quality is a vital consideration in assessing the environmental impact of military and civilian activities.

To better understand why our air quality has deteriorated and will probably continue to deteriorate, even if the most advanced technology developed to date is applied, one must recognize the factors responsible for air pollution problems. Air quality is intimately connected to population growth, expansion of industry and technology, and urbanization. In particular, the energy use associated with these activities is increasing at a rate that will see a doubling of the energy consumption in the next 25 years. In that energy use and air pollution are very strongly correlated, it seems imperative that we as a society examine each of our everyday activities in light of its potential impact on the environment. In effect, we must examine our life style both at a professional and a personal level to assure that the precious resource, clean air, is preserved.

The Clean Air Act of 1970 was established "to protect and enhance the quality of the nation's air resources so as to promote public health and welfare and the productive capacity of its population." In 1971, the Environmental Protection Agency set forth national primary and secondary ambient air quality standards under Section 109 of the Clean Air Act. The ambient standards are shown in Table 1. The primary standards define levels of air quality necessary to protect public health, while secondary standards define levels necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.

In addition, the EPA established emission standards for new stationary sources. Unless state or local standards are more stringent, these regulations

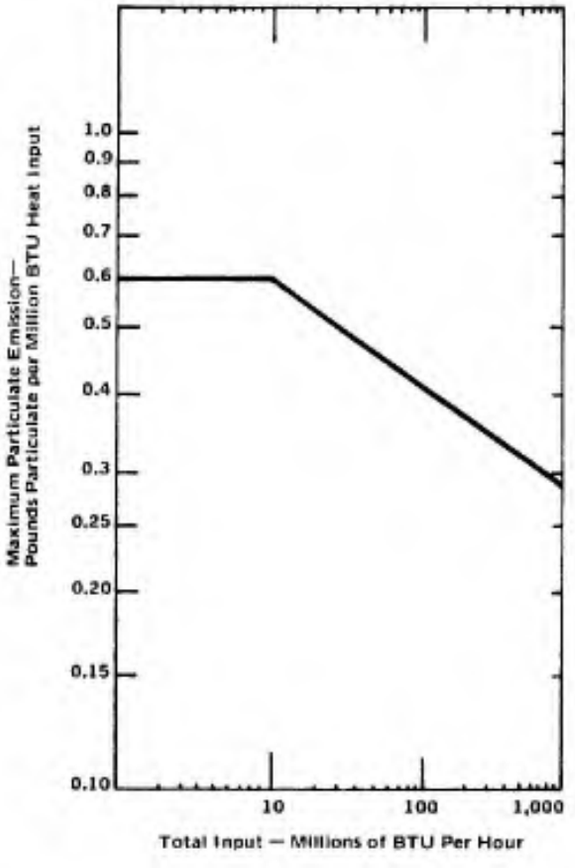
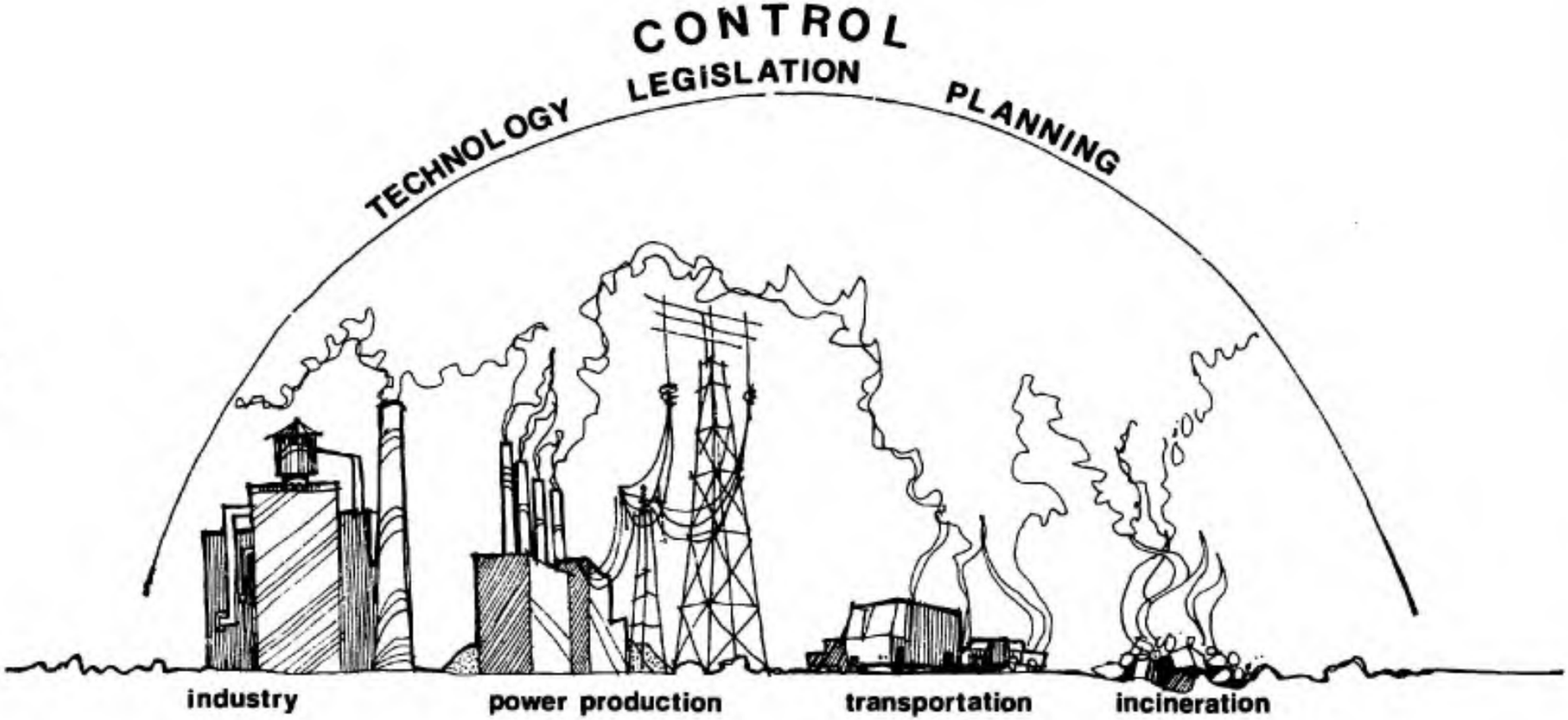


Figure 14. Maximum Emission of Particulate Matter from Fuel-Burning Installations for Both New and Existing Federal Facilities and Buildings (40 CFR 76; 36 FR 22417, 25 November 1971). Emission Standards for Five Specific Types of New Stationary Sources Are Shown in Table 2.



FACTORS IN AIR QUALITY - POLLUTION AND CONTROL

Table 1

Ambient Air Quality Standards
(EPA Regulation - 40 CFR 50; 36 FR 22384, 25 November 1971)

Pollutant	Ambient Standards
Carbon Monoxide (CO)	Primary and secondary standards are 10 milligrams per cubic meter (9 ppm) as a maximum eight-hour concentration not to be exceeded more than once a year, and 40 milligrams per cubic meter (35 ppm) as a maximum one-hour concentration not to be exceeded more than once a year.
Photochemical Oxidants	Primary and secondary standards are 160 micrograms per cubic meter (.08 ppm) as a maximum one-hour concentration not to be exceeded more than once a year.
Hydrocarbons (HC)	Primary and secondary standards are 160 micrograms per cubic meter (.24 ppm) as a maximum three-hour concentration (6 to 9 a.m.) not to be exceeded more than once a year.
Nitrogen Oxides (NOx)	Primary and secondary standards are 100 micrograms per cubic meter. (.05 ppm) on an annual arithmetic mean.
Sulfur Oxides (SOx)	Primary standard is 80 micrograms per cubic meter (.03 ppm) on an annual arithmetic mean, and 365 micrograms per cubic meter (.14 ppm) as a maximum 24-hour concentration not to be exceeded more than once a year. The secondary standard is 60 micrograms per cubic meter (.02 ppm) on an annual arithmetic mean, 260 micrograms per cubic meter (.1 ppm) maximum 24-hour concentration not to be exceeded more than once a year, and 1,300 micrograms per cubic meter (.5 ppm) as a maximum three-hour concentration not to be exceeded more than once a year.
Particulate Matter	Primary standard is 75 micrograms per cubic meter on an annual geometric mean, and 260 micrograms per cubic meter as a maximum 24-hour concentration not to be exceeded more than once a year. The secondary standard is 60 micrograms per cubic meter on an annual geometric mean, and 150 micrograms per cubic meter as a maximum 24-hour concentration not to be exceeded more than once a year.

Table 2
EPA Emission Standards for New Stationary Sources
(40 CFR 60; 36 FR 24876, 23 December 1971; Effective 17 August 1971)

Source	Emission Standards		
	Particulates	Sulfur Dioxide	Nitrogen Oxides
Fossil Fuel Fired Steam Generator (250 million BTU/hr input size and up)	No discharge shall be: (a) In excess of 0.10 lb per million BTU heat input (0.18 g per million cal), maximum 2-hour average. (b) Greater than 20 percent opacity, except that 40 percent opacity shall be permissible for not more than 2 minutes in any hour. (c) Where the presence of uncombined water is the only reason for failure to meet the requirements of paragraph (b) of this section such failure shall not be a violation of this section.	No discharge shall be in excess of: (a) 0.80 lb per million BTU heat input (1.4 g per million cal), maximum 2-hour average, when liquid fossil fuel is burned. (b) 1.2 lbs per million BTU heat input (2.2 g per million cal), maximum 2-hour average, when solid fossil fuel is burned. (c) Where different fossil fuels are burned simultaneously in any combination, the applicable standard shall be determined by proration.	No discharge shall be in excess of: (a) 0.20 lb per million BTU heat input (0.36 g per million cal), maximum 2-hour average, expressed as NO_2, when gaseous fossil fuel is burned. (b) 0.30 lb per million BTU heat input (0.54 g per million cal), maximum 2-hour average expressed as NO_2, when liquid fossil fuel is burned. (c) 0.700 lb. per million BTU heat input (1.26 g per million cal). (d) When different fossil fuels are burned simultaneously in any combination the applicable standard shall be determined by proration.
Incinerator (50 ton/day charging rate and up)	No discharge shall be in excess of 0.08 gr/scf (0.18 g/NM³) corrected to 12% CO_2, maximum 2-hour average.	N/A	N/A
Portland Cement Plants	No kiln discharge shall be: (a) In excess of 0.30 lb per ton of feed to the kiln (0.15 Kg per metric ton), maximum 2-hour average. (b) Greater than 10% opacity, except that where the presence of uncombined water is the only reason for failure to meet the requirements for this subparagraph, such failure shall not be a violation of this section. No clinker cooler discharge shall be: (1) In excess of 0.10 lb per ton of feed to the kiln (0.050 Kg per metric ton), maximum 2-hour average. (2) 10% opacity or greater. No discharge from any affected facility other than the kiln and clinker cooler shall be 10% opacity or greater.	N/A	N/A

Table 2 (Cont.)

Source	Emission Standards		
	Particulates	Sulfur Dioxide	Nitrogen Oxides
Nitric Acid Plants	N/A	N/A	No discharge shall be: (a) In excess of 3 lbs per ton of acid produced (1.5 kg per metric ton), maximum 2-hour average, expressed as NO_2. (b) 10% opacity or greater.
Sulfuric Acid Plants	N/A	No discharge shall be in excess of 4 lbs per ton of acid produced (2 kg per metric ton), maximum 2-hour average. No acid mist discharge shall be: (a) In excess of 0.15 lb per ton of acid produced (0.075 kg per metric ton), maximum 2-hour average, expressed as H_2SO_4. (b) Nitrogen Oxides 10% or greater.	N/A

Table 3

Effects of Some Major Air Pollutants on Man

Pollutant	Effect
Carbon Monoxide	Combines with hemoglobin in blood, displacing the vital oxygen that hemoglobin normally transports, thereby reducing the oxygen-carrying capacity of the circulatory system. Results in reduced reaction time and increased burden on pulmonary system in cardiac patients.
Photochemical Oxidants	Reacts with nitrogen and hydrocarbons in the presense of sunlight to form photochemical smog; causes eye, ear, and nose irritation and adversely affects plant life.
Hydrocarbons	Combine with oxygen and NO_X to form photochemical oxidants.
Nitrogen Oxides	Forms photochemical smog and is associated with a variety of respiratory diseases.
Sulfur Oxides	Associated with respiratory diseases and can form compounds resulting in corrosion and plant damage.
Particulate Matter	Injures surfaces within respiratory system, causes pulmonary disorders and eye irritation, and creates psychological stress. Results in economic loss from surface material damage.

Table 4

Estimated Emissions of Air Pollutants by Weight, Nationwide, 1970 (Preliminary Data) [41]

(Millions of Tons per Year)

Source	CO	Particulates	SO_X	HC	NO_X
Transportation	111.0	0.7	1.0	19.5	11.7
Fuel combustion in stationary sources	.8	6.8	26.5	.6	10.0
Industrial processes	11.4	13.1	6.0	5.5	.2
Solid waste disposal	7.2	1.4	.1	2.0	.4
Miscellaneous	16.8	3.4	.3	7.1	.4
Total	147.2	25.4	33.9	34.7	22.7
Percent change 1969-70	- 4.5	- 7.4	0	0	+ 4.5

[41] *Environmental Quality*. Third Annual Report of the Council on Environmental Quality (USGPO, August 1972) 450 pp.

apply to any new (effective 17 August 1971) building, structure, facility, or installation which emits or may emit any air pollutant. The standards, summarized in Table 2, are also applicable to modifications in existing plants.

For new and existing federal facilities and buildings not covered by the EPA Regulation discussed previously, the particulate emissions are limited to that shown in Figure 14.

The pollutants identified in the EPA ambient standards each have different effects on the health and welfare of man, as summarized in Table 3.

Transportation and fuel combustion in stationary sources contribute highly to air pollution in the United States, as shown in Table 4. Other activities involved with industrial operations and solid waste disposal also add a substantial amount of pollutants. Army activities include all of these, and therefore contribute to the overall problem of air pollution.

To develop a method to assess the impact of various activities on the air quality, the major elements of the air pollution problem were examined. These are (1) the presence of a source, (2) a means of transporting the pollutant to a receptor, and (3) the receptor. If any of these elements are removed, the problem ceases to exist. In examining sources, two types of classifications were used: particulates, and gases and vapors. Under particulates, one finds smoke, dust, and fumes, as well as liquid mists. To further identify the impact of these particulates, it was necessary to further subdivide into chemical and biological classifications. In particular, they were broken down into inorganic, organic, radioactive, and biological particulates. This allowed a certain detail of information without loss of generality. For example, if one is dealing with emissions from a foundry, it is necessary to recognize that particulates in the form of dusts and fumes are being emitted. It is also important, however, to know that these dust and fumes are inorganic and that they contain toxic metal compounds. The format presented allows this hierarchy of classification. Likewise, for gases and vapors being emitted from sources, this breakdown can also be made.

Finally, the environmental influence factors assess the transport mechanism of the pollutant. The pollutant transport, or lack of it, is controlled by meteorological and topographical factors. Clearly, less ground level pollutant concentration will occur on a flat open plain under windy conditions than in a valley under calm conditions. These factors and situations are accounted for in the attribute listings shown in Figure 15.

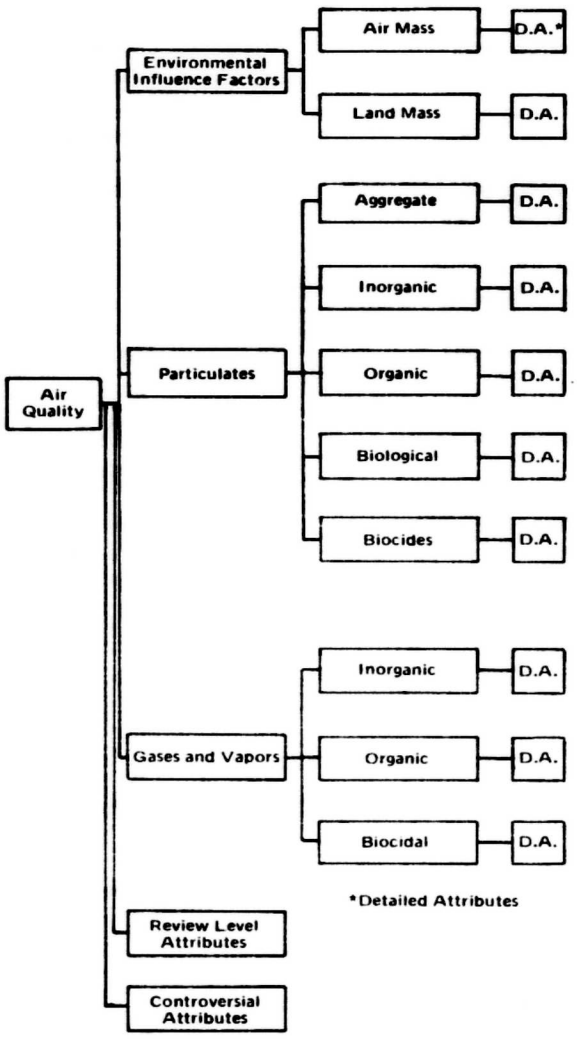


Figure 15. Attribute Hierarchy for Air Pollution

Nearly everyone has experienced the sight of black or red smoke being emitted from some industrial or utility source. The immediate impact of such an operation is to insult the aesthetic conscience of the observer. Some wonder under what license an organization has the right to degrade the air quality in such a blatant fashion. Beyond the

aesthetic considerations, one has to recognize that a great deal of material damage is done in the vicinity of a source because of the increased cleaning costs for clothing, houses, and automobile exteriors. Probably the most important impact, however, is on the health of the population. Medical authorities have demonstrated that definite correlations exist between high dust loadings in the presence of gaseous pollutants and reduced life spans of certain segments of the citizenry.

Another visible area of impact for gaseous pollutants is in the formation of smog. For example, in the Los Angeles, California, area, the concentration and duration of smog produced from the gaseous emissions of automobiles in the presence of sunlight has caused extreme eye irritation in the entire population and respiratory problems for persons suffering from respiratory and heart diseases. In addition, the presence of smog often obscures the mountain ranges in and around Los Angeles from the view of its citizens. These two examples illustrate how impaired air quality impacts on the populace.

When one considers the fact that air pollution knows no boundaries, and that it damages all citizens, whatever their social or economic status, it is not hard to understand why air quality has a strong interaction with the other specialty areas of this study. Air pollution has been definitely identified as having deleterious effects on humans, animals, plants, and materials. It has further been demonstrated that a degradation in air quality can be responsible for large-scale dislocation of industries and people. An example of this is the possibility of a ban on high sulfur coal sales in urban areas to control levels of oxides of sulfur. Such an air quality strategy could cause serious regional economic problems because of the effect of this strategy on the coal mining industry. A drastic reduction in air quality can also dramatically affect ecosystem behavior. One has only to look at the balded hillside downwind of a kraft paper mill to recognize this. Because of the potential deleterious effects of pollutants, land use patterns have been or will be changed: Orchid growers in California, for example are particularly sensitive to new industry locations which may emit ethylene.

If it is recognized that the average cost of air pollution to each of us is currently estimated to be between $70 and $90 per year, and that the capital cost of sulfur dioxide abatement equipment may be as high as 20 percent of capital cost of the process being controlled, it is clear that economics plays an essential role in air pollution. In assessing the interrelation of air pollution with transportation, one need only look at the smog problem of large urban areas. In attempting to control the emission from major air pollution sources, many processes rely on aqueous processes. In the case of abatement methods utilizing aqueous scrubbing devices, the wastewater associated with these processes is highly polluted. If these wastes are discharged untreated into the waterways or on to the land, the quality of the surface and groundwater can be seriously altered. In addition, the material removed during any abatement process has to be transportated away from the site and disposed of at some distant site. One strategy for disposing of solid waste is using sanitary landfills. This practice impacts upon the physiography of the locality. Finally, in each of the foregoing examples, the impact of noise and social variables on the environment is self evident.

Review Level Attributes. Offensive *odors* provoke people into complaining about air pollution. They may cause both mental and physiological effects such as nausea, headache, loss of sleep, loss of appetite, impaired breathing, and in some cases, allergic reactions. Community and personal pride and status may be adversely affected by obnoxious odors in the vicinity.

Poisonous substances describe those pollutants that have the potential to cause illness or death if present in small quantities. The presence of these substances is obviously related to the general health of a population, and therefore can be classified as controversial.

Smoke, dusts, and soot describe those pollutants, either solid or liquid particles, which are suspended in air. The source of these pollutants can be either natural or man-made. In either case, the presence of these substances can reduce the sunlight reaching the ground, affect visibility, and prove unsightly. The visibility of this type of pollution to the general public makes the abatement of smoke, dusts, and soot emissions extremely important.

Photochemical reactions involving hydrocarbons and nitrogen oxides produce particulates known as smog.

Smog and other irritants describe those pollutants that cause some discomfort to the general

Examples of Typical Detailed Attributes.

DUST AND/OR FUMES

A.

Dust is a loose term applied to solid particles predominantly larger than colloidal and capable of temporary suspension in air or other gases. Dusts do not tend to flocculate except under electrostatic forces; they do not diffuse but settle under the influence of gravity. Derivation from larger masses through the application of physical force is usually implied.

Fumes are comprised of solid particles generated by condensation from the gaseous state, generally after volatilization from melted substances, and often accompanied by a chemical reaction such as oxidation. Fumes flocculate and sometimes coalesce. Popularly, the term is used in reference to any or all types of contaminants, and in many laws or regulations, with the added qualification that the contaminant have some unwanted action.

B.

The physical properties of interest include the particle size, shape, surface area, density, electric charge, and radioactivity. The chemical properties include the material acidity, alkalinity, solubility and hygroscopicity. The biological properties include toxicity to human, plant, and animal tissue as well as taste and odor.

C.

The sources of man-made pollution cover a wide spectrum of types. Examples of dust-producing processes include crushing, grinding, screening, demolition, and milling. In addition, combustion sources, manufacturing processes, and agricultural activities contribute heavily to the airborne particulates. Chemical processes which involve solvent utilization and nuclear energy activities also contribute to this class of problems.

D.

For the most part, the effects of particulate air pollution are on health related to injury to the surfaces of the respiratory system, on the alteration of the climate near the ground, on reduced visibility, and on effects on materials. There are also studies which indicate that there is a definite relationship between levels of particulate pollution and levels of public concern over the problem. Further, there is evidence that liquid and even solid particles of some substances may be volatile enough to vaporize in the nasal cavity and produce gaseous material to suggest an odor.[42]

EXAMPLE OF A PARTICULATE ATTRIBUTE

[42] *Standards on Methods of Atmospheric Sampling and Analysis*, Committee D-22 (American Society for Testing and Materials, 1962).

FLY ASH

A.

Fly ash is the finely divided particles of ash entrained in flue gases arising from the combustion of fuel. The particles of ash may contain incompletely burned fuel.

B.

The physical properties of interest include the particle size, shape, surface area, density, electric charge, and radioactivity. The chemical properties include the material acidity, alkalinity, solubility, and hygroscopicity. The biological properties include toxicity to human, plant, and animal tissue as well as taste and odor.

C.

The main source of fly ash is from boilers with spreader stoker, underfeed stoker and pulverized fuel (coal) firing.

D.

For the most part, the effects of particulate air pollution are health related through injury to the surfaces of the respiratory system, on the alteration of the climate near the ground, on reduced visibility, and on effects on materials. There are also studies which indicate that there is a definite relationship between levels of particulate pollution and levels of public concern over the problem. Further, there is evidence that liquid and even solid particles of some substances may be volatile enough to vaporize in the nasal cavity and produce gaseous material to suggest an odor.

EXAMPLE OF A PARTICULATE ATTRIBUTE

INSOLATION

A.

Insolation is the rate at which the total solar energy--direct plus sky radiation-- is received on a horizontal surface.

B.

The isolation received at the surface of the earth depends upon the solar constant, the distance from the sun, the inclination of the sun's rays and the amount of energy depleted while passing through the atmosphere.

C.

Not all of the solar radiation comes directly from the sun. If a measuring device is pointed at a portion of the sky away from the sun, an appreciable amount of incoming energy recognizable as solar energy is detected. This is called sky radiation. It is the downward scattered component of solar radiation that is scattered by air molecules and by dust particles in the atmosphere.

D.

The insolation is the energy source for our atmosphere. The amount of insolation is an important factor in the formation of photochemical oxidants.

ENVIRONMENTAL INFLUENCE FACTOR ATTRIBUTE

SMOKE AND/OR SOOT

A.

Smoke is finely divided aerosol particles resulting from incomplete combustion. It consists mainly of carbon and other combustible material.

Soot is agglomerations of particles of carbon impregnated with "tar" formed in the incomplete combustion of carbonaceous material.

B.

The physical properties of interest include the particle size, shape, surface area, density, electric charge and radioactivity. The chemical properties include the material acidity, alkalinity, solubility, and hygroscopicity. The biological properties include toxicity to human, plant, and animal tissue as well as taste and odor.

C.

The sources of man-made pollution cover a wide spectrum of types. Examples of smoke-and soot-producing processes include combustion sources, manufacturing processes, and agricultural activities. Chemical processes which involve solvent utilization and nuclear energy activities also contribute to this class of problems.

D.

For the most part, the effects of particulate air pollution are on health related to injury to the surfaces of the respiratory system, on the alteration of the climate near the ground, on reduced visibility and on effects on materials. There are also studies which indicate that there is a definite relationship between levels of particulate pollution and levels of public concern over the problem. Further, there is evidence that liquid and even solid particles of some substances may be volatile enough to vaporize in the nasal cavity and produce gaseous material to suggest an odor.

EXAMPLE OF A PARTICULATE ATTRIBUTE

OZONE

A.

During daylight hours, oxygen (O_2) is oxidized to form a colorless gas called ozone (O_3).

B.

Ozone exhibits strong absorption bands in the ultraviolet spectrum at 200-300 millimicrons and in the infrared at about 9500 millimicrons.

C.

Ozone is also formed naturally by the action of solar radiation in the stratosphere at altitudes from 15,000 to 37,000 meters. In the lower atmosphere ozone is primarily generated in the atmospheric nitrogen dioxide photolytic cycle. The major man-induced source of nitrogen dioxide is high temperature combustion, e.g. power generation.

D.

Ozone has a profound effect on many polymers. Economically, rubber is the most important material sensitive to ozone. In particular, styrene-butadiene, natural, polybutadiene, and synthetic polyisoprene are unusually sensitive. Ozone also attacks the cellulose in fabrics and causes certain dyes to fade.

The major physiological effect on animals is on the respiratory system. The toxicity is greater for young animals and for exercising animals.

The effect of ozone on plants is very severe. Injury to vegetation was one of the earliest manifestations of photochemical air pollution (of which ozone is the major phytotoxicant). In regions were ozone is present high concentrations, one can expect extensive plant damage.[43]

The effect of ozone at normal ambient concentration on humans is not clear.

EXAMPLE OF A GASEOUS ATTRIBUTE

[43] *Air Quality Criteria for Photochemical Oxidants*, Publication No. AP-63 (National Air Pollution Control Administration, 1970).

population. This discomfort can manifest itself in eye irritation, severe coughing, headaches, or extensive damage to vegetation and/or materials.

Controversial Attributes. In considering possible controversial attributes, one can conclude that the attributes themselves are not controversial, but rather (1) the alleged effects attributed to them at normal ambient concentrations, (2) the cost of abating the pollutant given the degree of uncertainty of the effect, (3) the decision regarding what constitutes available technology, and (4) the time span necessary for compliance with some regulation.

The degree to which various air pollutants have been "proven" to be injurious to health and welfare is quite controversial. Until the state of the art of epidemiology is much further advanced, controversy will continue with regard to human effects. Eventually all alleged pollutants will be controversial in this respect. Currently, sulfur dioxide, oxides of nitrogen, and hydrocarbons fall into this category. In the near future, the so-called hazardous metals will fall into this category.

If the uncertainty claim regarding the effect of most pollutants is accepted, it is easy to see why many organizations argue against spending "inordinate" amounts of money on abating pollutants whose harmful effects have not been adequately demonstrated. This argument is usually coupled with a statement pointing up the need for money to be spent on other problems facing the nation such as poverty and urban renewal.

The controversy surrounding the availability of technology can be stated at its limits as follows: the accused polluter argues that unless a piece of abatement equipment has very nearly a probability of 1 for abating a pollutant both now and in the future, it is not available. The enforcer argues that the accused polluter should assume some degree of risk regarding the performance of abatement equipment because of the pollutant's harmful effects on our society.

The last area of controversy is the time for compliance. The polluter argues that even if technology is available to meet the regulations, there must be sufficient time to plan the installation and to raise the necessary monies to finance the installation. Further, time must be allowed for abatement equipment suppliers to meet the demand. The enforcer argues that this procedure is merely a delaying tactic that has already cost the United States much in terms of environmental quality and cost due to human, plant, and material damages.

Examples of present-day controversial areas are given below.

Because of the publicity given to the concept of clean air, it is mandatory that all visible *particulate emissions* be controlled. If smoke stacks, construction sites, or other dust-producing activities are allowed to go unchecked, one can expect an irate outcry from the citizenry affected by the offender.

Because of the insidious nature of the damage that can be done *radioactive emissions* will always be controversial. Radioactivity cannot be seen or felt. As a result, the average citizen has difficulty in rationally evaluating the environmental impact of any operation or activity involving potential radiation hazards. In any operation involving radioactive materials, it is imperative that a strong public education program be undertaken to inform the public about the safeguards that will be employed to protect the community.

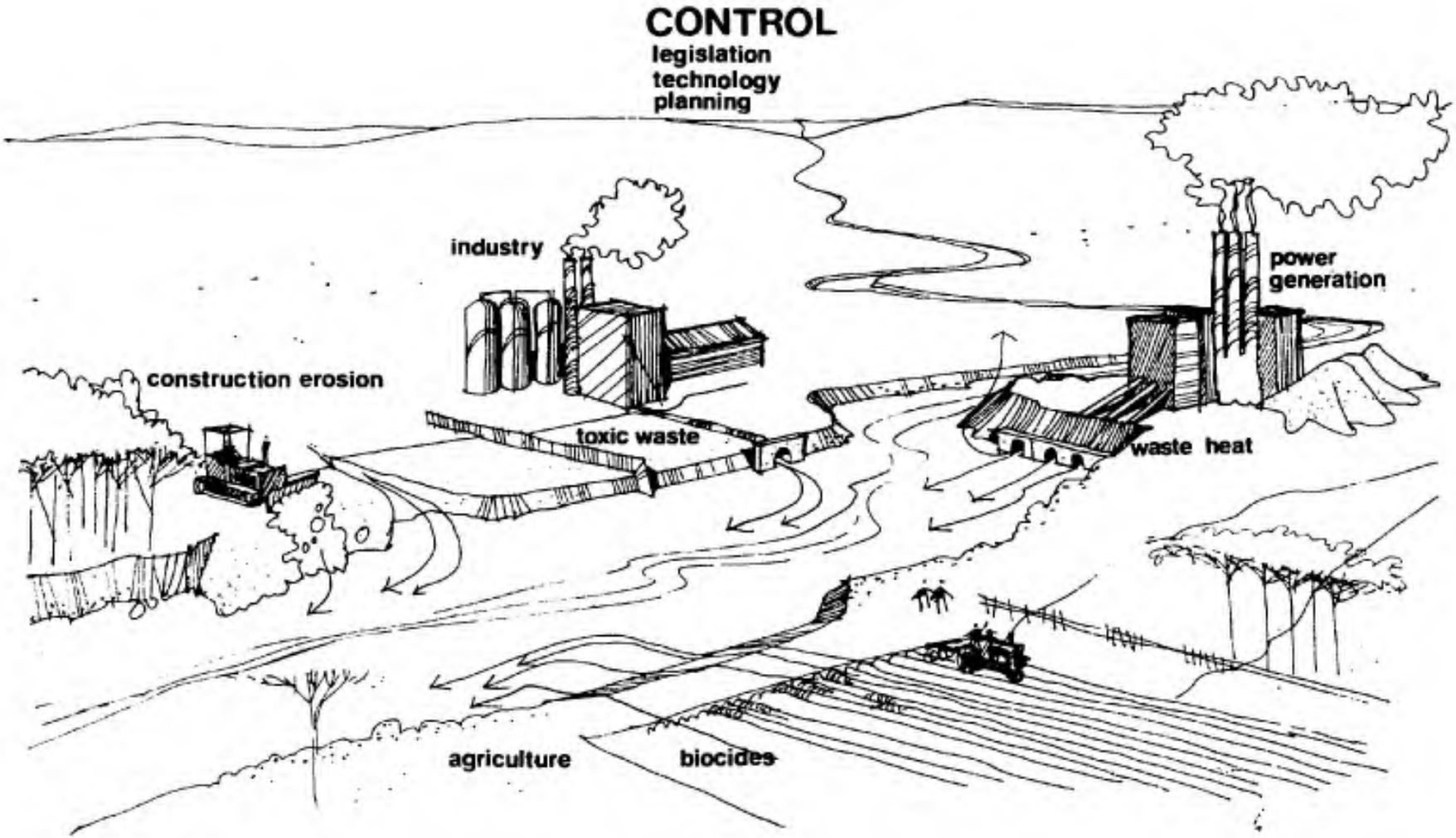
Photochemical oxidants derived from oxides of nitrogen and hydrocarbons, are the primary constituents of what is commonly called smog. Because these kinds of pollutants can cause photochemically formed haze, a severe reduction in visibility, and severe eye irritation, one can expect an aroused public whenever these conditions exist. The most important contributor to this problem is mobile sources.

Because of the concept of clean air, any disagreeable *odor* will not be tolerated by the public. Since odors are extremely difficult to identify and abate, this area will remain a source of controversy for some time to come.

Regarding *other areas*, it must be recognized that any pollutant can become controversial under the right conditions. If a pollutant is emitted under adverse meteorological and topographical conditions over a sufficiently long period of time, a pollution episode will eventually occur. The prevention of such controversy requires good planning and an awareness of the total environmental impact of any activity.

Selected Ramification Remarks and Mitigation Statements.

Ramifications: As the air quality scientist work-



SURFACE WATER QUALITY IMPACTORS

ed through the various BAAP lists he discovered a rather consistent repetition of ramification remarks and subsequent mitigation procedures. Consequently, he was able to list these alternatives in advance and then choose the appropriate remark for any given BAAP attribute intersection. A few of the ramification remarks follow.

1. Odors could be a problem if dredgings are not hauled away or treated.

2. Pollution resulting from evaporation from the fuel tank is low because aviation fuels with low volatility are generally used.

3. Any increase in personnel strength will require additional housing, transportation and utilities. Concommitant with all of these activities will be increased air pollution due to more automobiles, new construction (roads and structures), increased power plant and possible new industrial activity. When assessing the environmental impact on the air quality, each activity associated with the increase in personnel strength must be examined individually with respect to environmental quality.

4. The main contributor to air pollution from normal hospital operations is incineration of wastes. The mitigation techniques here include observing good incinerator operation practices or disposing of all wastes using nonincineration methods such as a sanitary landfill and another source of pollution is from the boiler plant supplying electrical power to the installation. At present, fly ash, sulfur oxides, and nitrogen oxide emissions should be controlled from power plants.

5. All roads leading to or from a hospital which are unpaved must be sprayed with water or oiled for control of fugitive dust.

Mitigations: Some selected mitigation procedures are:

1. Water spray on roads or working surfaces;

2. Oiling roads or working surfaces;

3. Hood operations in conjunction with abatement device(s) at some central location; and

4. Conduct operation only under light or calm wind conditions.

In addition, numerous hardware control devices were listed for appropriate BAAP attribute intersections.

Surface Water.

Introductory Commentary. Because water of high quality is essential to human life; because water of acceptable quality is essential for agricultural, industrial, domestic, and commercial uses, because most recreation is water based; and for less rational reasons, Army activities with potential effects on surface water are certain to be of appreciable concern to the taxpayers who support the Army's activities. Additionally, developments of recent years suggest that Americans are far more concerned about water quality than in previous years.

Perhaps the political process provides the best barometer to measure the extent of public concern about water quality. The United States House of Representatives and the Senate overwhelmingly enacted (over Presidential veto) the Federal Water Pollution Control Act Amendments of 1972.[4] This legislation, in general, calls for uniform application of "secondary treatment" by 1 July 1977, at publicly owned treatment works, and "application of best practicable control technology currently available for other point discharges." By 1 July 1983, point discharges other than publicly owned treatment works "shall require application of the best available technology economically achievable for such category or class, which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants."

Additionally, and significantly, the Act requires that agencies of the federal government comply with Federal, State, interstate, and local requirements respecting control and abatement of pollution to the same extent that any person is subject to such requirements. Potential impacts on surface water quality and quantity are certain to be of concern in assessment of the effects of many Army programs. Almost any activity of man offers the potential for impact on surface water through generation of waterborne wastes, alteration of the quantity and/or quality of surface runoff, direct alteration of the water body, modification of the exchanges between surface and groundwaters, through direct or indirect consumption of surface water, or because of other causes.

[4] *Federal Water Pollution Control Act Amendments of 1972*, Conference Report, 92nd Congress, 2nd Session, House of Representatives, Report No. 92-1465 (USGPO, 1972).

It is difficult to conceive of an alteration of surface water quantity or quality which is not accompanied by secondary effects. The physical, biological, and chemical factors influencing water quality are so interrelated that a change in any water quality parameter triggers other changes in a complex network of interrelated variables. Thus, while individual water quality and quantity parameters may seem far more amendmable to quantitative expression than parameters describing the quality of other sectors of the environment, the total effect of a particular impact on surface water may be as intangible as those on any sector of the total environment because of the complex secondary, tertiary, etc., effects.

It is difficult to categorize the nature of these interrelationships which establish the quality of surface waters. Some alterations in water quality cause transient perturbations which are overcome in time by the natural capacity of water bodies for withstanding certain insults. Other water quality changes are conservative and can only be mitigated by dilution. Some short changes in water quality may be devastating, while other water quality changes only are of concern if they are sustained over long periods of time so that cumulative effects can be manifested. Some changes in water quality may be discernible to the senses (but possibly may be of little consequence), while other changes may be apparent only to the most sophisticated chemist (but may be of crucial importance).

The potential environmental effects of the basic activities associated with Army programs considered in this section relate to *surface* water. The scope of this segment of environmental concern is construed to include consideration of water quality, and the desired quality requirements of various uses of water, including aesthetic enjoyment, aquatic ecology, and water quantity. Excluded from consideration is groundwater, although aspects of the considerations included here inevitably interface with groundwater, and the environmental attribute descriptions were developed so as to be usable for groundwater considerations as well.

Attributes of the environment readily could be categorized in most cases as being physical, chemical, or biological in nature. The three major types of attributes were categorized further as much as possible into groups of similar nature to form a hierarchy of environmental attributes. (See Figure 16).

Physical attributes of surface water could be categorized as relating to either the physical nature of the water body or to the physical properties of the water contained therein. Examples of individual environmental attributes in the former category would include the depth, velocity, and rate of discharge of a stream. Attributes of this type might be influenced by Army activities such as withdrawal of water, dredging, and clearing of vegetation. The other category of physical attributes, those related to the water itself, contained water characteristics such as color, turbidity, temperature, and floating solids. Many types of Army activities could influence the physical properties of water. A few examples are clearing of land and construction of hardstands, roads and rooftops (which might accelerate erosion, flooding and sedimentation), discharge of scale-laden boiler waters, and discharge of cooling waters. Some of the attributes included in this category, such as dissolved gases, and tastes and odors are manifestations of chemical properties of water, and serve to illustrate the occasional difficulty in categorizing attributes of the water environment.

Chemical attributes conveniently could be categorized as being organic or inorganic chemicals. However, two important types of chemical attributes, biocides and radioactive substances, transcended this subdivision and were established as separate categories. The inorganic chemical attributes of the surface water environment comprised the longest list of any of the categories. Some (like cadmium, lead, and mercury) represent inorganic chemicals with grave consequences to human health, some (notably phosphorus and dissolved oxygen) have severe effects on the water environment, while others (such as calcium, manganese, and chlorides), relate mainly to the economic and aesthetic value of water to man in his commercial, industrial, and domestic uses. Normal personal use of water by man increases the concentration of many inorganic chemicals in water. Additionally, almost any type of industrial activity and land drainage are sources. Because of the hundreds of thousands of organic (carbon-based) chemicals produced naturally and by man, most of the attributes contained in the organic chemical category were "lumped-parameters." Examples include BOD (biochemical oxygen demand), detergents, and carcinogenic (cancer-causing) substances. Some organic compounds are natural constituents of surface drainage and human and animal wastes, while others are unique to industrial activities and industrial products.

Biological attributes of the water environment conveniently could be categorized as pathogenic agents or aquatic life. Pathogenic (disease-causing) agents include certain virus, bacteria, protozoa, and other organisms, and they originate almost exclusively from human wastes. Aquatic life refers to the microorganisms and microscopic plants and animals including fish which inhabit water bodies. They are affected directly or indirectly by almost any natural or man-made change in a water body.

Although potential effects of impact on surface water were considered as effects on definite discrete "attributes" of the surface water environment, the impression must not be created that actual impacts are correspondingly well categorized. That is, nature does not necessarily respect man's discrete categories. Rather, actual impacts are "smears" comprised of effects of various severity on a variety of interrelated attributes. These interrelationships were handled by noting the attributes primarily affected by BAAPs and by relying on the descriptions contained in this section to point out the secondary, tertiary, etc., effects.

To illustrate the nature of interrelationship between environmental attributes, consider, as an example, a BAAP which involves removal of vegetation which shades a stream. The environmental attribute which would be indicated as being affected by this BAAP would be solar radiation intensity. The description of that attribute would lead to other attribute descriptions to reveal that growth of algae in the stream might be stimulated and cause a change in community maintenance (the numbers of organisms and composition of aquatic species in the stream). The pH of the stream could be affected by the growth of algae, and this in turn could affect the concentration of many of the chemicals in the stream by changing their solubility. Change in each of the chemical constituents affected could trigger further change in the complex system. Excessive growth of algae could, at some location, result in high BOD values and loss of oxygen from the stream. Clearly the interrelationships would not be limited to the stream, for evolution of gases from decomposition could create an air pollution problem. This and/or the green color of the stream could affect land use and cause adverse social and economic effects. The hierachy of surface water attributes is shown in Figure 16.

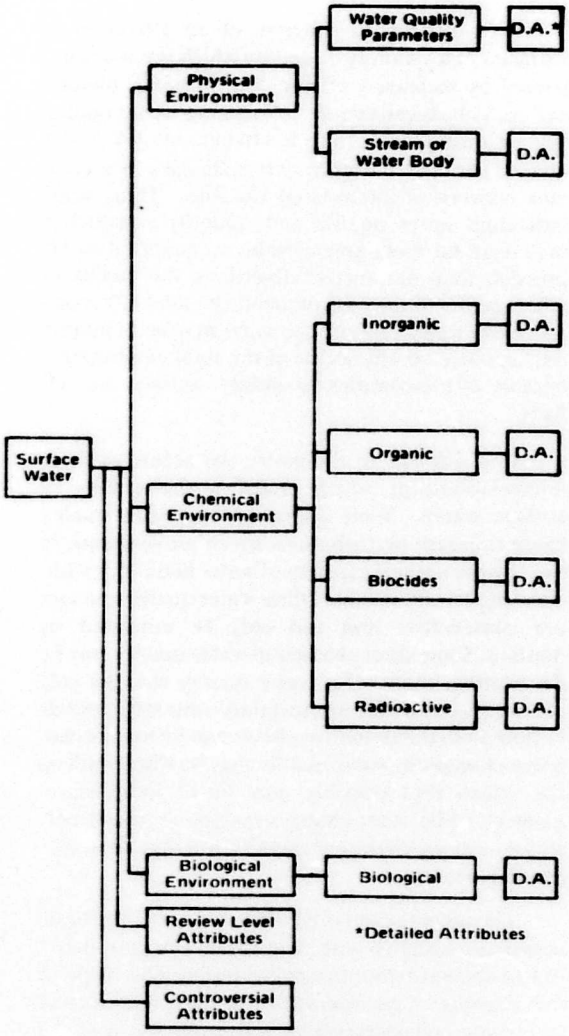


Figure 16. Hierarchy of Surface Water Attributes

Review Level Attributes. The review level attributes selected to describe the general surface water environment are:

1. Aquatic life;
2. Discharge and related physical properties of water bodies;
3. Appearance and other physical characteristics of water;
4. Toxic chemicals;
5. Pathogenic organisms; and
6. Chemical constituents interfering with aesthetic properties and potential use of water.

Examples of Typical Detailed Attributes.

MANGANESE

A.

Manganese is a metal which can cause aesthetic problems in water supplies. Its chemical behavior closely resembles that of iron.

B.

Like iron, manganese exists in both a soluble, reduced state and a less soluble, oxidized state. The oxidation state which prevails depends (as in the case of iron) primarily on the pH and/or Eh of the water system. Its form and concentration, can thus, be affected by activities such as impoundment of surface water (see Iron).

C.

While manganese may be naturally leached from mineral deposits, it is also a waste product of some industrial processes such as the manufacture of dyes, paints, explosives, steel alloys, glass, and dry-cell batteries.[49]

D.

While some evidence of manganese toxicity at high concentrations does exist, its limitation in waters is primarily because of aesthetic considerations. Manganese in excessive quantities imparts a metallic taste to water. Again, like iron, its precipitate (brown) is responsible for both turbidity and staining of laundry and plumbing fixtures. Growth of certain nonpathogenic microorganisms in water distribution systems may also occur when excessive quantities of manganese are present. These adverse qualities associated with manganese in water have prompted the U.S. Public Health Service to adopt a recommended manganese limit of 0.05 mg/1 in their Drinking Water Standards.[50] As with iron, many industrial activities (such as the production of textiles, high-grade paper, and food processing) would benefit from manganese concentrations considerably less than the U.S. Public Health Service Standards.

INORGANIC ATTRIBUTE
OF THE CHEMICAL ENVIRONMENT

[49] J. E. McKee and H. W. Wolf, *Water Quality Criteria.*
[50] *U.S. Public Health Service Drinking Water Standards.*

SUSPENDED SOLIDS

A.

Suspended solids are solids contained in water which are not in solution. They are distinguished from dissolved solids by laboratory filtration tests, and sometimes are called nonfilterable solids.[45]

B.

Suspended inorganic chemical precipitates such as calcium carbonate and iron hydroxide may be solubilized (converted to dissolved solids) under specific temperature and pH conditions. Conversely, conditions which cause dissolved solids to precipitate cause an increase in suspended solids. To illustrate, oxidation of soluble metals can produce insoluble forms (see Iron and Manganese, for example). Conditions which promote microorganisms in natural waters (see Plankton and Nonpathogenic Bacteria) increase the suspended solids content of water. Turbidity, settleable solids, and volatile suspended solids are included within the definition of suspended solids, and factors which affect these parameters would affect suspended solids also.

C.

Naturally, suspended solids result commonly from eroded clay and silt particles, organic debris, and plankton. Activities of man that increase erosion and contribute nutrients to water which can stimulate algal growth (see Nitrogen and Phosphorus) and increase the quantity of "naturally" produced suspended solids. Gravel washings and mine tailings, steel mill wastes, waterborne domestic wastes, and dust are other man-related sources of suspended solids in water.[46]

D.

While the U.S. Public Health Service Drinking Water Standards [47] do not specifically restrict suspended solids, their quantity is indirectly controlled by the limit on turbidity. The limitation is imposed for aesthetic reasons. Municipal and industrial water treatment costs could be increased by increased concentrations of suspended solids. Also, low suspended solids concentrations benefit industrial production of textiles, paper and pulp, beverages, dairy products, steel, and other materials.[48] Aesthetic enjoyment of natural water may be impaired by an increase in suspended solids as may the quality of water for swimming. Excessive suspended solids can be deleterious to fish and other aquatic life by coating gills, blanketing bottom organisms, reducing solar radiation intensity, etc. (see Settleable Solids and Turbidity).

WATER QUALITY ATTRIBUTE
OF THE PHYSICAL ENVIRONMENT

[45] *Standard Methods for the Examination of Water and Wastewater*, 13th Edition (American Public Health Association, 1971).
[46] J. E. McKee, and H. W. Wolf, *Water Quality Criteria*, Publication No. 3-a (California Water Quality Control Board, 1963).
[47] *U.S. Public Health Service Drinking Water Standards*, Public Health Service Publication No. 956 (U.S. Dept. of HEW, 1962).
[48] J. E. McKee, and H. W. Wolf, *Water Quality Criteria*, Publication No. 3-a (California Water Quality Control Board, 1963).

COD

A.

The chemical oxygen demand (COD) of water is a measure of the quantity of oxygen needed for chemical oxidation of organic matter and reduced chemicals. COD is closely related to biochemical oxygen demand (see BOD) but differs from BOD in that it includes the oxygen demand of substances which cannot be oxidized by natural biological processes. In addition, whereas BOD values conventionally indicate the amount of oxygen required during a five-day period. COD values indicate the total amount of oxidizable material present.

B.

COD quantities are affected mainly by the amount of organic matter present and not by the biochemical stability (biodegradability) of the organics. Reduced inorganic chemicals such as nitrites, ferrous iron and sulfides can increase COD values of water.

C.

Domestic sewage, livestock wastes, and wastes from food processing, pulp and paper mills, and most other industries contribute COD to waters. Natural, biologically productive waters (see Nitrogen and Phosphorus) rich in algae and other plankton contain high CODs. Also, natural drainage may contain appreciable COD.

D.

The significance of COD values of wastes and waters is most often interpreted in conjunction with BOD values. Because COD measurements alone do not provide information concerning the biological stability of organic matter, a waste containing a high COD will not necessarily exert a high oxygen demand as a result of biological decomposition. However, wastes containing high CODs have the potential of depleting oxygen from waters (see BOD and Dissolved Oxygen) and therefore should be subjected to further analysis. In addition, water or wastes with high COD values but low BOD values are of concern because of the possibility that they may contain stable organic compounds of health significance (see Carbon Chloroform Extract and Carcinogenic Substances).

ORGANIC ATTRIBUTE OF THE CHEMICAL ENVIRONMENT

PATHOGENIC VIRUSES

A.

Pathogenic viruses which may be associated with polluted waters include adenoviruses, Coxsackie viruses, ECHO viruses, the viruses of infectious hepatitis, polio viruses, reoviruses, and others.

B.

Because of the difficulty of isolating and sustaining pathogenic viral cultures in the laboratory, comparatively little is known of their potential to withstand adverse environmental conditions. However, viruses in polluted waters may be reduced in number due to aging, adsorption, and other natural causes.[51] Studies have shown that some viruses can withstand chlorine concentrations which are lethal to enteric bacteria. For example, the virus of infectious hepatitis is more resistant to chloramines than are waterborne pathogenic bacteris.[52] Because of this the coliform group (see Pathogenic Bacteria) is not a valid indicator of the presence or absence or pathogenic viruses.

C.

Enteric virsus are of considerable concern to water supply officials. All wastes containing fecal material (septic tank discharges as well as municipal and some industrial wastes) are a possible source and hence, a potential hazard if they come in contact with water to be used for drinking or recreation.

D.

Techniques for routine analysis of water for viruses are currently unavailable. For this reason, the coliform count is used as an indirect means of indicating the potential of virus contamination of water. This procedure is probably not reliable. Further research in this area may permit the establishment of a direct or more appropriate measure of possible virus contamination of water. In the meantime, pathogenic viruses remain a somewhat mysterious, yet potentially dangerous, entity in waters.

ATTRIBUTE OF THE BIOLOGICAL ENVIRONMENT

[51] J. E. McKee and H. W. Wolf, *Water Quality Criteria*, Publication No. 3-a (California Water Quality Control Board, 1963).
[52] *U.S. Public Health Service Drinking Water Standards*, Public Health Service Publication No. 956 (U.S. Dept. of HEW, 1962).

It is seen that the review level attributes correspond generally to subdivisions in the hierarchy of physical, biological, and chemical attributes presented previously, except that chemicals were subdivided as being toxic or of aesthetic or economic concern (rather than as inorganic, organic, radioactive, or biocidal). Brief and general descriptions of the review level attributes follow.

It is not possible to specify the nature of the environment required to protect *aquatic life*, because various members of the aquatic community have widely different requirements. Through slow natural evolutionary processes, aquatic organisms become adapted to particular conditions and, in nature, live where those conditions prevail. It is the preservation of those ambient conditions which is essential to the protection of aquatic life. Man is capable of affecting abrupt change in water quality or the physical nature of water bodies so as to render aquatic environments suddenly unsuitable for residents uniquely adapted to the former conditions.

Considerations of aquatic life and associated environmental requirements are complicated by the relationships between members of the aquatic community. Some members of the population are basically "producers" who manufacture food by the process of photosynthesis. Others are "consumers" who eat producers or other consumers, and finally, some organisms can be categorized as "decomposers." They feed on the waste products and carcasses of all members of the aquatic community, and in the process, recycle to basic constituents of the living material for reuse by the producers and other organisms. Because of these interdependencies, a change in a chemical or physical property of water as a result of man's activities may have no direct effect on particular members of the aquatic community, but still may prove devastating because of effects on other members of the community.

This orderly and interdependent association of organisms in the aquatic environment is expressed by the term community maintenance. It is a sort of composite picture of the types and numbers of various species in an aquatic environment and of the level of their productivity. The goal of surface water environmental control might be considered to be to leave this parameter unaffected.

One of the important water quality parameters from the standpoint of aquatic life is the dissolved oxygen concentration. It is influenced by the amount of biologically degradable organic material, called BOD, in the stream because microorganisms use oxygen in decomposing organic wastes. Temperature, and especially the rate of change of temperature, are critical parameters which can be affected by waste discharges, reservoirs, and other factors. The pH value (a measure of relative intensity of acidic or alkaline conditions) is another parameter frequently influenced by industrial-type wastes which, in turn, can influence aquatic life.

Settleable materials can be particularly troublesome because they cover the bottom of water bodies, interfere with organisms which spend all or part of their lives there (the benthos), and interfere with the feeding of some fish. Other solid particles in water might be objectionable because they interfere with the penetration of sunlight or because they foul the gills of fish.

Many chemical substances are toxic to aquatic life. Chemicals such as heavy metals, ammonia, and pesticides fall into this category. A major problem with potentially toxic materials is that they become concentrated in the aquatic food chain so that relatively massive doses can be delivered to fish (or man) even though the concentration of the offending chemical may be low in the water itself.

Aquatic life must be considered to be a water quality attribute which potentially is very controversial. This is because seemingly subtle changes in water quality may trigger changes in aquatic life which are of significant concern, and because such changes may be readily observable.

Of major concern to all users of water is the *amount of water available for use and the variability of the supply*. This is true for water uses as diverse as recreation, power production, domestic or industrial water supply, navigation, fishing, boating, swimming, and aesthetic enjoyment. Army activities which alter or potentially alter the quantity of water available or the time distribution of that availability are highly likely to cause controversy.

In nature, the quantity of surface water available is established by complex factors related to precipitation and other climatic conditions, evaporation and transpiration (water loss from plants), losses of water to the ground, and discharges of water from the ground. Abundant opportunities exist for man to alter the complex system which determines the quantity of available water at any particular time.

More detailed descriptions of factors influencing water quantities are contained in the discussion of "maximum discharge," minimum discharge," "dependable yield," and "rate of change of

discharge." However, in general, any Army activity which alters the composition, texture, or slopes of land surface may affect the quality of precipitation which reaches surface water bodies and the rapidity with which it reaches the water body. To illustrate, replacement of dense vegetative cover with a paved surface or roof substantially increases the amount of water which runs off of land to surface water bodies during and immediately after storms, and in many cases reduces the time required for the water to arrive in the stream, river, or lake. Significant flooding and pollution can result. Even comparatively small activities of this type could have appreciable impact in a watershed with limited total drainage area, or could create substantial local problems by straining the capacity of storm sewers. Additional water-related effects attributable to alterations of land surface include changes in available groundwater quantities due both to alteration of the fraction of precipitation which percolates into the ground and to alteration of the rate of water loss due to evaporation and transpiration. Any such change in groundwater quantities would, in turn, affect flow of groundwaters to rivers, lakes and streams. Diminishment of such base flow of streams would be especially apparent during dry weather periods when no surface runoff contributes to stream flow. Additional activities which could alter flow from ground to surface waters would be excavations which intercept flow of groundwater and construction of detention basins for runoff from hardstands and surfaced areas.

Construction of reservoirs on streams to retain peak flows for later discharge during time of need can significantly increase minimum discharges and decrease maximum discharges. However, such construction may substantially alter water quality, aquatic ecology, and other environmental characteristics at the reservoir site and downstream from it. Among the subtle, but omnipotent changes potentially caused by impoundment of water are thermal stratification, alteration of the temperature of water, and reduction in availability of dissolved oxygen.

As suggested by the previous paragraph, none of the activities of man which affect water quantity are without accompanying effects on water quality and aquatic ecology. Some such effects are caused by alteration of the physical characteristics of the stream. Others are caused by changes in the quality of water entering a water body. For example, clearing of the land not only would influence the amount of runoff from an area, but also would alter the sediment content of the runoff water.

Army activities which potentially cause alteration of the *physical characteristics of water* are of special concern because, unlike many of the chemical and biological attributes of water, physical attributes can be readily detected by human senses. Many of the physical attributes of water quality have obvious and direct association with the aesthetic enjoyment of water (for example, turbidity, color, gross solids, floating solids, and tastes and odors). However, these and other physical attributes of water quality can alter aquatic ecology and interfere with other intended uses of water equally as well as the "invisible" chemical and biological attributes of water quality.

Discharge of waterborne wastes from domestic and industrial activities could directly influence each of the physical water quality parameters listed in the previous paragraph. Similarly, materials which affect the physical properties of water could be carried by storm runoff. Suspended solids and turbidity are notable examples.

But adverse physical attributes of water are not caused only by discharge of materials to streams which directly influence physical parameters. Indeed, physical characteristics often are changed due to biological and chemical phenomenon in water. To illustrate, discharge of phosphate--a dissolved chemical constituent of water—to a water body might appreciably increase the growth of algae—a biological constituent of water. The presence of increased numbers of algal cells would directly effect turbidity, color, suspended solids, and volatile suspended solids—all physical characteristics. Furthermore, normal metabolism of the algae would appreciably change the dissolved gas content of water (especially carbon dioxide and oxygen) and would result in production of taste—and odor-causing substances. Accumulation of appreciable quantities of settleable solids (algal cells) on the bottom of the water body would produce active biological decomposition which could contribute further to the taste and odor problem and, through gas production, give rise to floating solids and to gross solids.

Major activities of man which have direct influence on physical properties of water are the discharge of inadequately treated waterborne wastes and alteration of the cover or slope of land so as to increase the amount of sediment carried to streams by runoff. A "physical" characteristic of water with appreciable current controversial concern is oil. Massive introduction of oil to water commonly is associated with pipelines, oil tankers, and drilling

operations. However, a little oil goes a long way in water, and highly undesirable conditions can be created by improper control of oil in conjunction with vehicle maintenance and similar operations.

Many of the chemicals which may be discharged to natural waters as a result of man's activities potentially may be toxic to aquatic life, to wildlife, to terrestrial crops, or to human consumers. Gross generalizations as to the types of material which cause *toxicity* are not possible because of differences in the susceptibility of various organisms. For example, ammonia is the form of inorganic nitrogen most toxic to fish, but the form of inorganic nitrogen of concern to humans (infants) is nitrate. But, nevertheless, certain chemical substances are generally toxic, and these are discussed here.

Consideration of the toxicity of chemicals to organisms are complicated by factors such as synergism and antagonism (the rendering of toxic agents more or less effective because of the presence of other materials, and by the accululative, long-term effects of some toxic materials, and by the accumulation of certain toxic materials in organisms to the extent that low concentrations in water become increased by orders of magnitude by the time they are consumed by organisms at the top of the food chain. Additionally, the form of certain toxic materials in water (and, hence, their toxicity) is influenced by other water quality parameters such as pH.

Notable among the toxic materials which find their way into water are pesticides. They are designed by man to be toxic, but their presence in water normally is not. Regrettably, they are an example of materials which may concentrate in aquatic food chains. Most modern pesticides are synthetic organic compounds and they are representative of a broader group of compounds fabricated by man. Many of these synthetic organic compounds are not readily degraded by microorganisms, and thus they persist in the environment. Regrettably, some of then are known to be carcinogenic (cancer-causing). But, in general, the real toxicity of such compounds is unknown because their effects may result from long-term exposure to low levels of the substances. Capability for measuring the amounts of such materials in water currently is lacking, and gross, lumped parameters like the carbon chloroform extract are used.

Not all toxic compounds in water are synthetic chemicals devised by man, however. Others are naturally occurring substances which may be present naturally, but, more often, are the result of man's activities. Examples are the heavy metals such as cadmium, mercury, lead, zinc, copper, selenium, chromium, and others. In addition to the acute toxicity typically exhibited by heavy metals, many of them cause chronic effects because of their accumulation in organisms; lead is a classic example. Other common toxic substances are cyanide and fluorides, although almost any chemical can be toxic if present in sufficient concentration.

Radioactive substances can be acutely toxic. However, under most environmental conditions, it is their effect on the rate of genetic change and their accumulation in aquatic food chains which limits their desirable concentration in water.

Pathogenic organisms associated with surface water principally are associated with human waste discharges and cause enteric-type diseases. In general, these organisms do not find a suitable home outside of the human body. While they are unable to multiply in the water environment, they may persist for long periods of time and retain their capability for causing disease if injested by a human.

Pathogenic bacteria which may find their way to surface waters include the causative agents for disease such as typhoid fever, paratyphoid fever, cholera, bacillary dysentary, and gastroenteritis. In addition to these enteric diseases, bacteria which cause tuberculosis, brucellosis, and diseases of the eye, ear, nose, and throat may be waterborne. The latter organisms are, of course, of particular concern in waters used for swimming. Of the protozoan organisms, *Entamoeba histolytica* is of most concern in water because it causes amoebic dysentery. The organism is of particular concern because it is capable of forming a cyst which is unaffected by modern disinfection practices. Among the human virus particles, the one causing most problems in water is the causative agent of infectious hepatitis. Helminths (worms) are additional waterborne infectious organisms.

In general, the source of pathogenic organisms is the waste products of infected individuals. However, some pathogens (notably those causing typhoid fever and amoebic dysentery) are able to establish permanent residence in the intestinal tract of recovered victims (who may not realize they had the disease and that they are excreting the pathogenic organisms daily). Thus the wastes of healthy individuals also are sources of pathogenic organisms.

In the highly developed countries of the world, the reservoir of waterborne disease is small. However, eternal vigilance is necessary to prevent eruption of such disease.

It is hard to isolate pathogenic organisms in water, for their concentration may not be extremely high—even in grossly polluted waters. Thus the absence of a specific pathogen from a particular water sample would have limited significance with regard to the biological quality of a water body. Because of this difficulty, tests for specific pathogenic organisms rarely are conducted (indeed, tests for the virus of most concern in water, the virus of infectious hepatitus, currently are impossible). Instead, water is monitored for "indicator" organisms known to be associated with human wastes. The indicator most commonly used is the coliform group. Their presence in water is taken as being indicative of the possible presence of pathogenic organisms, as well. Regrettably, they are not good indicators of the resistant protozoan spores, for the spores may endure after all the indicator organisms have expired. Available information also would indicate that coliforms are not reliable indicators for virus particles.

At some concentrations and under certain circumstances, any chemical constituent of water could be considered to *interfer with the aesthetic properties and potential use of water.* However, as used here, the category is reserved for those chemical constituents which are not noted for their severe toxic effects, but which nevertheless interfere with use and enjoyment of water.

Prime examples would be nitrogen and phosphorus. Their effect is the opposite of toxic materials—they stimulate growth. But this increase in the productivity of photosynthetic organisms can have severe aesthetic and economic effects—particularly in lakes. Indirectly it also can have toxic effects because of the complex interrelationships in surface waters and because depletion of oxygen due to respiration of algae during the night and periods of low solar radiation intensity.

Calcium and magnesium are other chemicals which interfere with water uses—in this case, because they interfere with cleansing action of detergents. This "hardness" of water is aesthetically objectionable and has economic consequences in households and industries.

Iron and manganese may cause water to have color and to stain clothes and household fixtures. These two chemicals provide good opportunity to point out the complex interrelationships which exist between each constituent of water and other water quality parameters. The solubility of iron and manganese is dependent on the pH and Eh, and the many possible impacts on water which could change Eh and pH also would influence the form of iron and manganese.

Chlorides and sulfates are other inorganic chemical constituents of water which appropriately could be considered in this section on chemicals which most commonly cause aesthetic problems or interfere with beneficial uses of water. Many others could be cited.

Often, biodegradable organic constituents of water (BOD) can be considered as influencing water in aesthetic and economic ways. This is because of the influence of these compounds on aquatic ecology and because of potential odor problems caused by oxygen depletion in water bodies. Phenols and detergents are other organic compounds which can have severe effects on the aesthetic quality and economic value of water (although both of these compounds also can have toxic effects).

Controversial Attributes. The detergent issue embraces two aspects of water quality. One concerns the *synthetic detergent* itself, and the other involves the phosphates commonly used as "builders" in commercial packaged detergent products.

The controversial problem of the persistence of detergent suds due to the relative nonbiodegradability of some synthetic surface active agents has largely been circumvented by adoption by the detergent industry of biodegradable products. Further discussion of this matter is contained in the description of the detergent water quality attribute.

The phosphate controversy was created by the switch to biodegradable products. Commerical detergents probably constitute the greatest single source of phosphorous discharged to surface waters, and phosphate, an essential nutrient for all living things, may stimulate growth of organisms—especially algae—in surface waters. The effect of such growth is to hasten the aging (or eutrophication) of surface waters and to create potentially adverse aesthetic problems.

The controversial nature of the detergent issue has been intensified by efforts of the advertising industry to sell particular products and by public airing of disagreements within the scientific com-

munity—especially within the federal government. Concern over phosphorous in detergents has led to development of substitute builder materials; some of which may have effects more adverse than phosphates. At present, the emergence of a suitable substitute for phosphates in detergents is not apparent.

Living organisms require a wide variety of nutrients to sustain their growth. In a given water body, any one of these nutrients (phosphorous, nitrogen, carbon, iron) might be limiting. In those cases where phosphorous limits the amount of possible growth, concern over the discharge of phosphorous to surface waters because of detergent use is justified. Additional detail on the significance of phosphorous in water is contained in the description of that surface water quality attribute.

Addition of *fluorides* to public water supplies to reduce the incidence of decayed, missing, and filled teeth long has been a controversial issue. The beneficial effect of proper amounts of fluorides in the diet of preadolescent children has been intensively studied and generally accepted by the scientific community. Resistance to use of public water supplies as a convenient vehicle for inclusion of fluoride in diets of all children has been vigorously and effectively resisted by some groups on the basis of religious, political, and other arguments. More discussion of the significance of fluorides in water is contained in the description of that water quality attribute.

Because of man's basic need for water for life and his industrial, agricultural, and recreational activities, matters related to available *water quantities* always have been, and will continue to be, controversial. Additionally, the vivid destruction of life and property by flooding renders potentially controversial any activities which would cause an increase in water discharges or a decrease in the capacity of streams for handling such discharges.

Mercury is a highly toxic compound which, currently, is controversial because of the rather recent recognition of its prevalence in surface waters. Whereas concern over the undesirable effects of mercury is well founded, there is evidence to suggest that its presence in the water environment and in aquatic plants and animals is not solely a reflection of modern industrial development. Rather, presence of mercury in the water environment due to natural causes may have been common in the past. A more detailed consideration of mercury and of the biological transformations influencing its significance in water is found in the description of surface water quality attributes.

Oil is a water quality parameter of appreciable current concern. The controversial nature of oil in water is kindled by its visible and tragic effect on water fowl and by current concern with mammoth oil tankers, offshore drilling, and the North Slope of Alaska. Additional discussion is contained in the description of the oil water quality attribute.

Common recognition of *thermal pollution*, the fact that an increase in the state of thermal excitation of water molecules can constitute pollution, is a comparatively recent development. Realization of the convenience and effectiveness of water as a coolant and projections of future increases in cooling water requirements makes the issue one of appreciable concern. And current scrimmages between power interests and conservationists with accompanying construction delays and "brownouts" give the issue a controversial flavor.

Potential impact of thermal pollution on aquatic ecology is considerable as is the difficulty and expense of minimizing it. Further discussion of thermal pollution is contained in the description of the temperature water quality attribute.

Waves of controversy concerning *other potentially controversial aspects* of water quality are generated with changes in technology, public sentiment, and legislation. Speculation as to incipient waves is contained here.

Concern appears to be increasing over crop fertilization practices. Present fertilizers and fertilizer application rates, times, and techniques are not optimized with regard to environmental control. Principal environmental concern about fertilization practices concerns fertilization of surface waters to cause an increase in eutrophication rates and potential toxicity of ground and surface waters to infants due to increased nitrate concentrations. Another agricultural practice which already has developed as a controversial issue is the use of herbicides and insecticides (see Pesticides).

As public appreciation of the potential health threat of trace quantities of biologically resistant, synthetic, organic compounds in water develops, it would seem that the presence of these substances will develop as a more controversial issue. Similarly, increased controversy over human viruses in water can be anticipated—especially if the virus of infectious hepatitis continues to evade isolation in

the laboratory and as waterbone cases of the disease continue.

Selected Ramification Remarks and Mitigation Procedures. The following are ramifications with respect to selected construction and mission change activities.

1. The major anticipated effect of clearing, grubbing, stripping, and grading operations on surface water quality is an increase in turbidity and suspended solids due to erosion. However, in particular cases, additional significant chemical changes in water quality may occur. The effect on chemical attributes of ground and surface waters is dependent upon both the characteristics of soil and geological formations and on surface water runoff conditions. It is conceivable that, depending on local circumstances, almost any inorganic constituent could be carried to ground or surface waters in the dissolved form or to surface water in the suspended form as a result of clearing, grading, and related activities.

2. Depending on the nature of the local conditions, the same changes in inorganic chemical constituents of water as described in (1) could be of concern. In addition, depending on the nature of a particular channel, gross changes in the biological attributes of existing streams or of the new channel could occur.

3. Depending on the nature of the particular material being dredged, almost any inorganic constituent could be introduced into water because of dredging activities. Special problems might be encountered in dredging materials accumulated on the bottom of water bodies as a result of domestic and industrial waste discharges. Potentially toxic heavy metals from industrial waste discharges are examples of such constituents. In addition, biodegradable organic material on the bottom of water bodies may be dispersed into water as a result of dredging. These materials could cause oxygen depletion and aesthetically undesirable conditions.

4. Depending on local geological conditions, a variety of inorganic constituents could be introduced into water through drainage of subsurface excavations.

5. In some instances, dewatering could involve discharge of appreciable quantities of "muck." Under these conditions, (3) could apply.

6. The effect of a change in personnel strength on water quality may be less significant than effects caused by the activities of the personnel. These potential effects should be determined by consulting the appropriate BAAPs which describe the function or task of the added personnel.

The following is a list of mitigation procedures.

1. Avoid clearcutting, restore vegetative integrity, control runoff, divert drainage from adjacent areas, and exercise similar measures to avoid erosion.

2. Control runoff and leachate from decomposing masses of vegetation.

3. Control runoff by diversion of drainage from adjacent areas, slope stabilization, and similar measures.

4. Alternate site selection.

5. Channel lining when appropriate, control of slope of channel bottom, control of slope of channel sides, avoidance of interference with natural vegetation.

6. Controlled inland disposal of dredgings, proper selection of type of dredging equipment.

7. Use of stilling basins, selection of point of discharge of drainage water to minimize effect on surface waters.

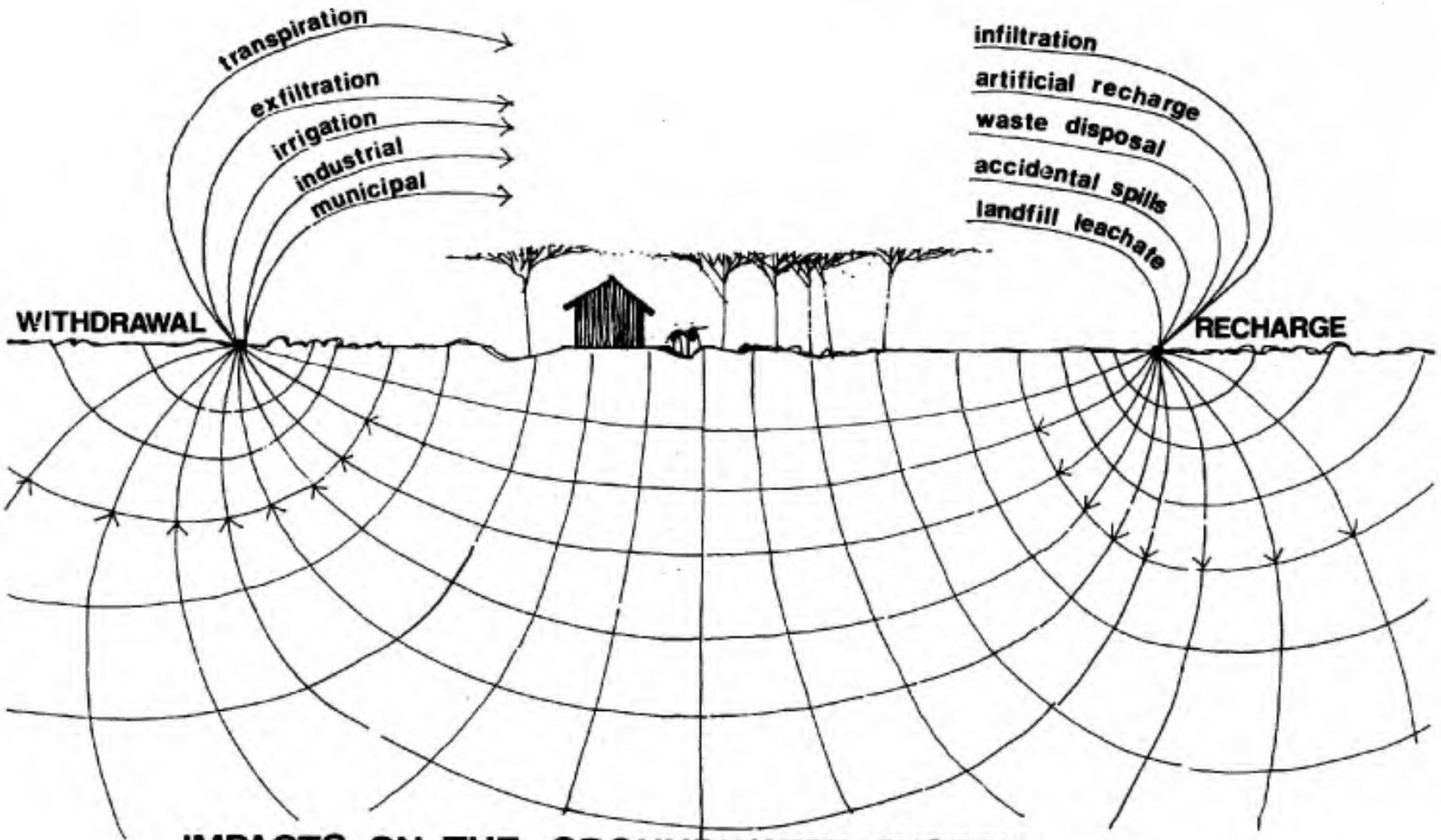
8. Use of stilling basins, control of rate of dewatering.

9. Control of runoff from fresh bituminous surfaces, avoidance of application prior to rainfall, control of spillage, etc., of bituminous materials.

10. Control of wash waters from trucks and batch plants, use of stilling basins, avoidance of dumping of form oil, selection of batch plant location to minimize potential for water pollution.

Groundwater.

Introductory Commentary. The hydrologic environment is composed of two interrelated phases: groundwater and surface water. Impacts initiated in one phase eventually affect the other. For example, a groundwater system may charge one surface water system and later be recharged by another surface water system. The complete assessment of an impact dictates consideration of both groundwater and surface water. Thus pollution at one point in the system can be passed throughout and consideration



IMPACTS ON THE GROUNDWATER SYSTEM

of only one phase does not characterize the entire problem.

Impacts on the groundwater system come not only from the introduction of pollutants by the surface water recharge area, but also from direct physical actions on the groundwater system. For example, one such physical action could be that of groundwater drawdown. This action draws more water from the system than is put in and as a result lowers the water table, thus disturbing the equilibrium of the system. To re-establish the equilibrium, the disturbed system must draw fluid from other sources. Supplies could come from an underlying brine system, for example, which seeps into the depleted area or from a contaminated surface water system. Fluids drawn from either of these sources could contaminate the groundwater system. Another physical action that can result in groundwater contamination is that of using deep wells for waste disposal. This action has two possible reactions. First, in areas of fractured substrata, leakage through the soil can contaminate the groundwater supply. Because of a high degree of mobility through the soil, contamination of this kind is increased when disposal involves inorganic solutions. Secondly, in areas containing fault lines, deep well injections increase the fault line pressure which can result in earth tremors. These tremors could cause substrata fracturing with resulting increased potential for groundwater contamination.

A compounding factor to be considered, in addition to all potential contamination sources, is the relatively low flow rates of groundwater systems. As a result of these low flow rates, pollutants are not readily diluted and thus tend to remain localized problems for long periods of time. These low flow rates also make it uneconomical to mechanically purify contaminated groundwaters.

Legislative efforts are currently being made to prevent the future contamination of groundwater systems. One such effort is a proposed Hazardous Wastes Management Control Act which would nationally regulate surface and underground disposal practices. On the state and local level, some areas are protecting their water supplies by regulating landfill locations.

The Federal Water Pollution Control Act (PL 92-500), enacted in October 1972, established the following programs pertaining to groundwater:

1. The Administrator of the EPA shall, after careful investigation, and in cooperation with other Federal agencies, state and water pollution control agencies, interstate agencies, and the municipalities and industries involved, prepare or develop comprehensive programs for preventing, reducing, or eliminating the pollution of the navigable waters and groundwaters and improving the sanitary condition of surface and underground waters (Sec. 102 (a)).

2. The Administrator of the EPA shall, in cooperation with the states, and their political subdivisions, and other federal agencies establish, equip, and maintain a water quality surveillance system for the purpose of monitoring the quality of the navigable waters and groundwaters and the contiguous zone and the oceans (Sec. 104 (a) (5)).

a. These plans shall include a process to (i) identify, if appropriate, salt water intrusion into rivers, lakes, and estuaries resulting from reduction of fresh water flow from any cause, including irrigation, obstruction, groundwater extraction, and diversion, and (ii) set forth procedures and methods to control such intrusion to the extent feasible where such procedures and methods are otherwise a part of the waste treatment management plan (Sec. 208 (b) (2) (I)).

b. These plans shall include a process to control the disposal of pollutants on land or in subsurface excavations within such area to protect ground and surface water quality (Sec. 208 (b) (2) (K)).

4. State authorities must determine that well injection or disposal will not result in the degradation of ground or surface water resources (Sec. 502 (6)). In addition, states must demonstrate adequate authority to control the disposal of pollutants into wells in order to have their permit programs approved by the Administrator of the EPA (Sec. 402 (b) (1) (D)).

Section 313 of the Federal Water Pollution Control Act directs each department, agency, or instrumentality of the executive, legislative, and judicial branches of the Federal Government to comply with federal, state, interstate and local requirements respecting control and abatement of pollution. Presidential exemption is possible; however, *no* exemption may be granted from the requirements of Sec. 306 (National Standards of Performance) or Sec. 307 (Toxic and Pretreatment Effluent Standards).

To analyze the potential impact of an activity on the groundwater system, a set of monitorable indicators were developed. The attributes Figure 17, consider the chemical and physical aspects of the groundwater system. The physical portion is characterized by water quality parameters (i.e., turbidity, color, temperature) and aquifer characteristics (i.e., depth, yield, recharge rates). The water quality parameters are used to indicate potability, while the aquifer characteristics indicate the accessibility and support capability of the groundwater supply. The chemical portion is characterized by indicators, such as inorganic, organic, biocidal, and radioactive chemical compounds. All these indicators concern themselves with the level of toxicity, taste, color, and odor of the groundwater supply.

Impacts by BAAPs on the groundwater system permeate many other technical areas. Air and surface water systems are related to the groundwater system through the hydrologic cycle. Impacts affecting the quality of the groundwater system also can affect the health of the community and drawdown can cause marked changes in land use patterns and regional ecology. Changes in land usage, regional ecology, groundwater quality or supply result in disturbances in the economics of the region. Such changes also impact the sociology of the region by causing people to change life styles and reevaluate their living standards.

Review Level Attributes. Aquifer yield describes the general availability of the total groundwater system to supply water for human uses. An aquifer is defined as an earth material capable of yielding water to a well in usable quantities. Aquifer yield includes all attributes in aquifer characteristics under the heading "Attributes of the Physical Environment" (Figure 17). It includes decreases in water resources resulting from overpumping or restricting the movement into or through the aquifer. Conversely, it can apply in some circumstances to increased water availability due to increased water entering the system which may result in raising the water table, accompanied with high water problems in soils and water in excavations.

Chemical water quality describes the general chemical character of groundwater which may render it unfit for certain uses. Chemical quality includes all the inorganic and organic chemicals found in natural waters, and for which humans, other animals, and vegetation have moderate to high tolerance. Changes in chemical quality may make water unfit for some uses while still fit for drinking purposes.

Physical water quality describes the attributes of groundwater which reflect on its desirability for irrigation, industrial, and municipal usage. Bad color, taste, or odor may make the water highly undesirable for human consumption even though it would not be harmful. Turbidity, dissolved gases,

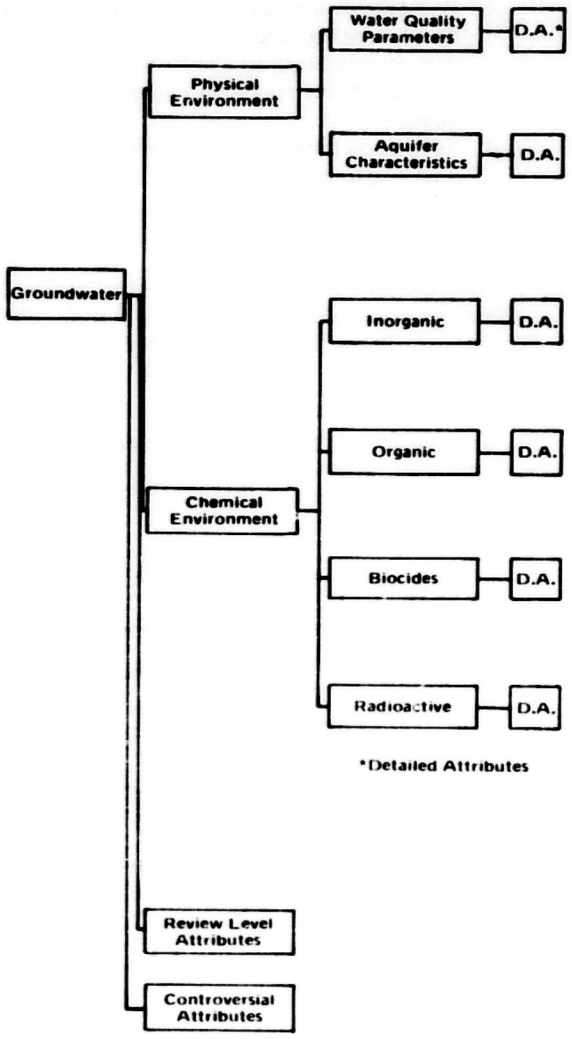


Figure 17. Attribute Hierarchy for Groundwater

Examples of Typical Detailed Attributes.

AQUIFER PARAMETERS

A.

An aquifer is defined as a natural earth material, either consolidated or unconsolidated, which will yield an adequate quantity of water for the desired purpose. Thus, there is no definite quantitative definition of aquifer; what is considered an aquifer for a farm water supply would not be an aquifer for an industrial water supply. An aquifer can be described, however, by a group of physical parameters; the following parameters are used to describe an aquifer:

1. Porosity is the ratio of voids (pores) to total volume of rock or soil.
2. Permeability is a quantity which describes the ability of rock or soil to transmit water either through the pores or fractures.
3. Transmissibility of an aquifer is equal to the permeability times the thickness of the aquifer. It is the transmissibility and pressure (see piezometric surface) which determine the potential yield of an aquifer.
4 Storage coefficient is a quantity used to describe the elastic response of the water and aquifer to pumping or injecting.

B. N/A

C.

Decreases in transmissibility can occur by plugging the pores of the aquifer. During pumping this can be the result of turbulence in the well bore from high pumping rates which move the fine-grained materials near the well. During injection clogging of the formation can occur from suspended solids or bacterial action of the injected fields.

D.

Decreased transmissibility of an aquifer will result in a decrease in the quantity of water potentially available from, or which can be injected into an aquifer. In regions dependent upon groundwater for water supplies this could be highly desirable.

TYPICAL GROUNDWATER AQUIFER
CHARACTERISTIC ATTRIBUTE

OILS

A.

Oils are potential ground and surface water pollutants of recent public concern. The term oil includes gasoline, crude and refined oils, kerosene and other petroleum products.

B.

The fate of oil in water depends on the biodegradability of the oil, sedimentation of oil contacted with settleable solids, and drift, which is influenced by wind and tides.[53]

Principal sources of oil in water are oil contaminated ballast and bilge waters, pipeline leakage, oil wells, refineries, outboard motor exhaust, vehicle maintenance centers, and industries which utilize oil.[54]

D.

The taste and odor caused by oil renders water unpalatable, at concentrations lower than those causing adverse health effects. The U.S. Public Health Service Drinking Water Standards limit oil concentrations in water supplies only by the 0.2 mg/1 limit on carbon chloroform extracts (see CCE) which also includes many other organic materials. From an economic standpoint, oil is of concern because its presence in water can cause tainting of fish flesh, damage to coastal resort areas, problems in industrial boiler and cooling waters, objectionable tastes in industrially processed food, and difficulties in water treatment facilities.[55,56] Aquatic life also may be adversely affected by oil. The coating of waterfowl, plankton and benthic regions as well as interference with photosynthesis and atmospheric reaeration can all result from excessive concentrations of oil.[57] One part of oil per billion parts of water has been reported to cause perceptible odors and 25 gallons of oil per square mile of water surface have been reported to be visible.[58]

TYPICAL PHYSICAL GROUNDWATER QUALITY ATTRIBUTE

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[53] National Technical Advisory Committee, "Water Quality Criteria," report to the Secretary of the Interior (1968).
[54] J. E. McKee and H. W. Wolf, *Water Quality Criteria*, Publication No. 3-a (California Water Quality Control Board, 1963).
[55] J. E. McKee and H. W. Wolf, *Water Quality Criteria*.
[56] National Technical Advisory Committee, "Water Quality Criteria."
[57] J. E. McKee and H. W. Wolf, *Water Quality Criteria*.
[58] J. E. McKee and H. W. Wolf, *Water Quality Criteria*.

DISSOLVED GASES

A.

Gases resulting from naturally occurring processes in the earth occur in groundwater. Common, naturally occurring dissolved gases are hydrogen sulfide (H_2S), methane (CH_4), and carbon dioxide (CO_2). Hydrogen sulfide causes severe taste and odor problems (see Sulfur); methane is explosive when mixed with air (5 to 15 percent methane in air); carbon dioxide affects the hardness of water (see Calcium and Magnesium).

B.

The solubility of gases in water is dependent on both the temperature and pressure of the water.

C.

Pumping of groundwater results in the lowering of pressure on the water to atmospheric and the release of dissolved gases. Disposal of plant or animal wastes (such as garbage or sewage sludge) into or on the ground where water infiltrates to the water table results in gases entering the groundwater system.

D.

The explosive nature of methane, a tasteless and odorless gas, makes it extremely hazardous to man if allowed to accumulate in enclosed places. Buildings where methane can accumulate must be vented. Methane, as with natural gas used in heating, is hazardous to animals breathing the fumes. Hydrogen sulfide is most toxic to fish and other aquatic life (see Sulfur).

TYPICAL ORGANIC GROUNDWATER QUALITY ATTRIBUTE

IRON

A.

Iron can exist in water in both the oxidized (ferric) and the reduced (ferrous) forms. Under most conditions the ferrous state is more highly soluble.

B.

The solubility of iron is a function of its oxidation state which in turn is an intimate function of pH and Eh. Low values of both pH and Eh (generally associated with low dissolved oxygen concentrations) enhance iron solubility by reducing insoluble ferric precipitates to soluble ferrous ions. Conversely, creation of higher Eh and pH conditions could result in precipitation of iron by converting it to the ferric form. The form and amount of iron in water thus can be affected by many activities which affect dissolved oxygen and pH such as impoundment of water, discharge of BOD, etc.

C.

Many ground waters low in dissolved oxygen and contacted by iron mineral deposits contain significant concentrations of ferrous iron. Corrosion of iron substances (pipes and water containers) is another major source of iron in water. Industrial processes which may contribute significant quantities of iron to water include steel pickling and mining with its concomitant acid mine drainage.

D.

Iron limitations in water are due to primarily aesthetic and economic reasons. Excessive iron, when precipitated, causes objectionable turbidity and staining in both domestic and industrial waters. High iron concentrations impart a bitter taste to water along with fostering the growth of several species of microorganisms. Such iron containing waters are unfit for industrial processes such as textile, pulp and paper, and beer production. To avert the objectionable consequences of high iron concentrations the U.S. Public Health Service Water Standards suggest a limit on iron of 0.3 mg/1, and much lower values are, in fact, desirable. Under extreme conditions of iron precipitation in streams, fish could be adversely effected by coating of gills and covering of eggs.

TYPICAL GROUNDWATER INORGANIC
WATER QUALITY ATTRIBUTE

and water temperature have less direct effect on human consumption (except as related to the former three attributes), but many industrial processes are sensitive to changes in these attributes.

Toxics describes the presence of heavy metals, carcinogenic substances, or other organic, or inorganic chemicals which, even in low concentration, may be harmful to human or animal life. This includes all chemical attributes, organic or inorganic, which are deemed harmful by U.S. Public Health Service Water Quality Standards.

Controversial Attributes. Controversy may arise over public concern for almost any of the groundwater attributes; this concern will generally be expressed in terms used to describe the grouped, or review level attributes. Groundwater is an unseen resource about which the public is poorly informed and has many misconceptions, but this does not necessarily mean that its concerns are ill-founded.

The prospect of an inadequate *water supply* always causes public concern. This may be commonly expressed by the public as "lowering of the water table," although other attributes may be the cause. The lowering of the water table or piezometric surface (often mistakenly referred to as the water table) may cause public controversy even in regions almost wholly dependent upon surface waters as a water supply.

Deterioration in the *chemical quality of groundwater* as a result of many activities is always controversial. Often changes in chemical quality are gradual and go unnoticed by the public until tastes or odors develop, or until change in the effectiveness of cleaning products are noted. When deterioration has occurred unnoticed over long periods, the chemical deterioration is often attributed to the latest, closest, or most disliked activity (BAAP) in the area.

The changes in the *physical water quality* which are most likely to be controversial are color, tastes, and odors. These in turn are usually indirect results of other attributes being adversely effective. For example: small increases in iron content of water cause severe staining of basins and other fixtures, and increases in manganese content may turn the water black; increases in total dissolved solids frequently impart a salty taste to the water; and H_2S gas may enter the water system as a result of lowering water levels. Conversely, a great improvement in water quality may cause controversy by making the water taste "flat" to the user.

The presence of *toxic chemicals* or carcinogenic substances in a water supply will always cause public controversy since the results can be severe, and are readily apparent.

Controversial Activities in Relation to Groundwater. As a result of public concern for the environment and the necessary impact on the environment of man's activities, many activities may cause public controversy. Below is a list of activities which may effect many different attributes of the environment, and about which there is considerable public and scientific concern. The following may be considered to create public controversy:

1. Deep well disposal of waters and wastes;
2. Surface disposal of wastes;
3. Groundwater mining; and
4. Drainage.

Deep well disposal is the practice of pumping wastes into deep rock formations for disposal. This has been practiced for over 35 years by oil companies; they reinject brine waters produced with the oil into the producing formation to maintain the reservoir pressure. Injection of industrial wastes into deep groundwater reservoirs has come increasingly into use over the past decade as pressures to clean up the environment have increased. There are now over 200 such wells in operation in the United States.

The concept of deep well disposal of wastes is considered by some to be basically a good one—especially that of injecting hard-to-treat industrial wastes into zones which are not fresh water resources (some natural groundwaters have salt concentrations ten times that of seawater) and are isolated from usable water resources by natural barriers. Considerable scientific research is presently being directed toward deep well disposal problems, and scientists disagree on the adequacy of the present technology for safe disposal. There are several limitations upon which there is general agreement:

1. Relatively small volumes of fluid can be disposed of in this manner.

2. The injected fluid must be free of suspended solids which may clog the pores of the receiving stratum.

3. The injected fluid must be free of organic matter which can cause growths in the well, thereby clogging the formation.

4. The injected fluid must not cause chemical reactions to occur with the formation water, which may close the pores of the rock.

Deep well disposal cannot be practiced everywhere, and there have been several failures causing severe environmental damage. These failures include migration of disposed fluids and displaced natural brines into fresh water zones through old unplugged (and unknown) wells or through natural rock fractures; overpressuring resulting in fracturing the rock and in blowing the well head off, spilling disposed fluids onto the ground and into nearby streams; and injection of fluids has been shown to indirectly trigger earthquakes.

Prior to deep well injection regional hydrogeologic and geophysical studies must be carefully conducted to determine the areas in which deep well disposal might be feasible, and the horizons into which fluid can safely be injected. This must then be followed by detailed study of each individual site, testing the injection horizon, the continuity of the confining horizon, and allowable potential injection pressures. Even with all these precautions there is no 100 percent guarantee of safe conditions. This fact, along with the volatility of the whole issue of waste disposal, makes deep well disposal highly controversial.

Surface disposal of wastes is the practice of dumping and/or burying wastes on land. This is the old garbage dump or its modern version, the sanitary landfill. The sanitary landfill is an operational technique designed to control vectors and insects, and, if properly located and operated, it has no direct effect on the groundwater system. Location of a landfill on porous soil, however, can impact an overdrawn groundwater system in a high water table area. Landfill leachate solutions collect in the porous surface soils and flow into the surface water system. The groundwater system, in an effort to reestablish equilibrium, will draw fluids from other sources and, because of the high water table, it may draw water from the contaminated surface water system. Proper operation and landfill site location can, however, prevent this from happening.

The relatively few cases of serious groundwater pollution that have occurred from dumps and landfills, considering the great number of randomly located sites, show the high natural filtration capacity of earth materials for the contaminants produced. Disposal of hazardous chemicals and low level radioactive wastes may be feasible at surface sites, provided extra care is exercised in the locating and engineering of the fill.

Most people recognize that waste disposal is necessary, although they wish complete recycling were possible. Incineration of the wastes does not solve the problem as is commonly believed; the ash contains most of the inorganic chemicals present in the original waste, and it is the inorganic chemicals which constitute the greatest environmental hazard in land disposal. For the individual the question is, "why near me?"

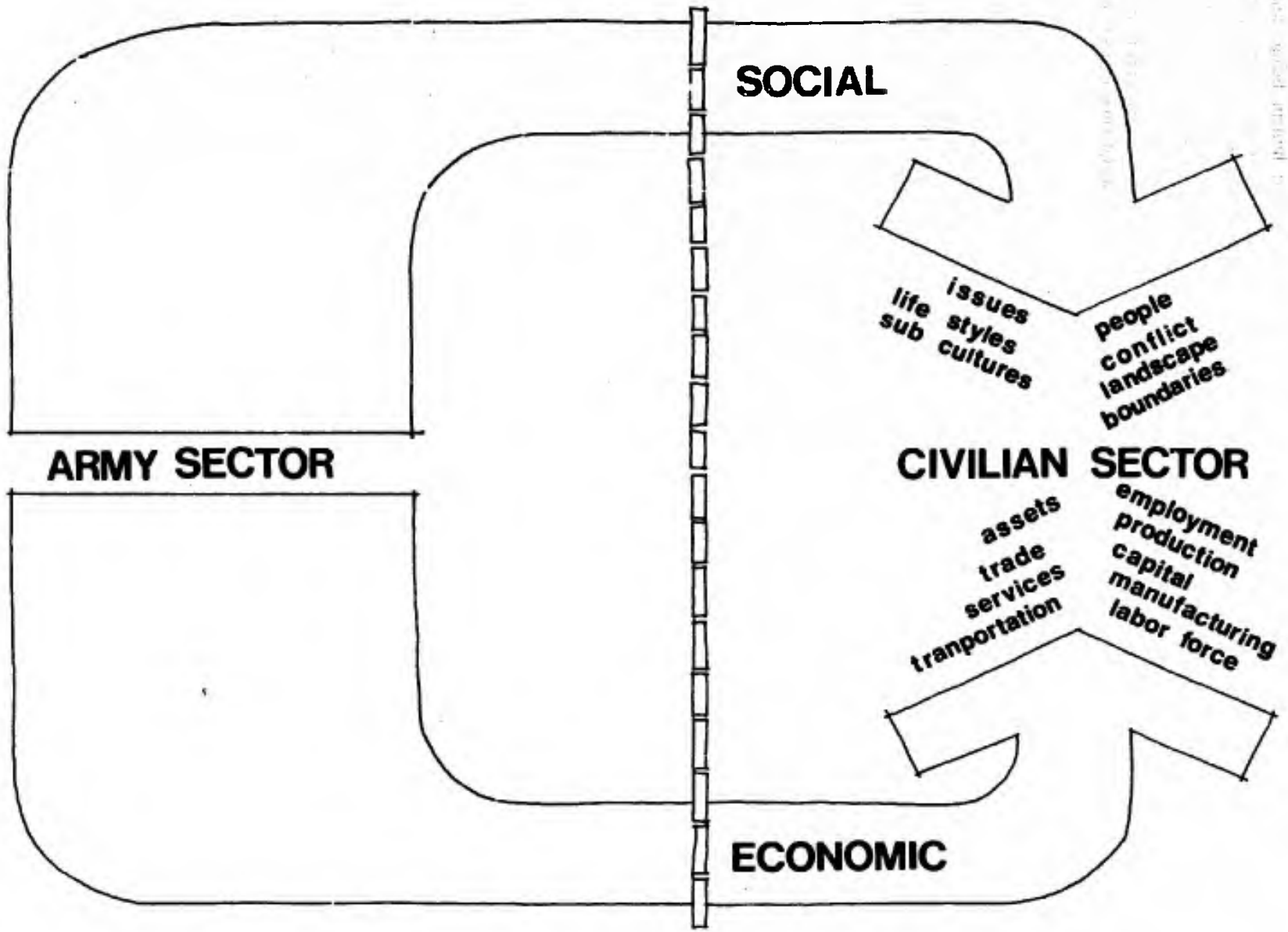
Groundwater mining is the practice of pumping greater volumes of water from the ground than can enter the groundwater reservoir through natural or man-induced processes. This results in the lowering of the water table of a surface aquifer or piezometric surface of an artesian aquifer, and the eventual depletion of groundwater as a resource.

As a result of heavy groundwater withdrawals, ground subsidence may sometimes occur. The seriousness of this environmental hazard depends on the geographical and topographical conditions present; portions of major coastal cities have been known to drop close to, or even below, sea level.

The lowering of pressure in fresh water aquifers may allow salt water to enter the aquifer either from the ocean or from other aquifers containing salt water. The lost aquifer is extremely difficult and slow to reclaim. Salt water intrusion can be minimized by a number of methods, including recharge and physical barriers.

Generally, the most serious aspect of groundwater mining, that of land subsidence, goes unnoticed by the general public unless damage occurs to structures, a rare occurrance. However, the overdraft of the aquifers and resulting depletion of the water resources or salt water intrusion often causes public concern, especially in a water-short region.

Drainage is a large part a surface water problem which directly affects groundwater. In many low, water soaked areas, such as bogs and shallow lakes, surface and groundwaters are intimately related. The ground serves either as a source or drain for many bogs, and the draining will alter the water table. The general lowering of the water table, in turn, which occurs in flat, humid areas from sewer and basement construction, may drain shallow lakes and bogs.



SOCIO-ECONOMIC IMPACTS OF ARMY ACTIVITIES

Intentional drainage of the land for agricultural and urban purposes has been practiced for over a century in the United States. With the increased urbanization over the last few decades, the remaining "natural areas" have become more desirable both for urban development and preservation. As a result, intentional or unintentional draining of shallow lakes and bogs has come under increasing public scrutiny.

Agricultural drainage in arid lands has resulted in increased salts being leached from the soils and entering the river systems. In some regions salt concentrations of river waters have more than doubled, rendering the waters of little value.

Selected Ramification Remarks and Mitigation Procedures. Direct impacts on the groundwater system by the construction process are limited to the site refuse disposal and excavation areas. Woodworking, concrete masonry, and plaster repairs will have an environmental effect only where discarded building material has to be disposed of. In this area, BAAPs relating to waste disposal and sanitary landfills are of concern.

Mitigations: Contamination by construction site refuse disposal can be minimized by proper disposal site location and by the use of proper disposal practices. In areas of high groundwater, excavations are sealed to avoid seepage problems. The impermeable barrier can also protect the groundwater system when the excavation contains a vapor-permeable storage tank. The vapors will be unable to travel horizontally through the soil and thus be forced to vent to the surface.

Sociology.

Introductory Commentary. Men everywhere react to situations as they define them, and if men define a situation as real, then that situation is real in its consequences. This tendency has become a principle of advertising, public and community relations, and "image management." That scientists and engineers think a solution of their own requirements is perfectly rational, economic, and altogether good, may be beside the point. If that solution provokes a public controversy because numerous people and organizations believe it threatens a certain quality of life which they value, then the consequences will be real. Hence there is the great practical importance of socio-psychological thinking by environment-conscious planners and managers.

Environment is surroundings. Social environment is people surroundings: human beings and their products, their property, their groups, their influence. Such are the surroundings of almost any undertaking. There is no one social environment; there are many. Each event—be it the construction of an Army facility, the testing of weapons, a straining mission, or whatever—so long as it is at a different place, has its own social environment, its own surroundings.

The effects of a project or plan on people and their responses may be direct and immediate or remote and attenuated. But it is likely that people are somehow, sooner or later, implicated. And this is apt to be the case even if a BAAP occurs on a deserted island, miles from human habitation, and the action is triggered by electronic push buttons.

Prerequisite to any rational assessment of human impacts and responses is an inventory and depiction of the relevant social environment. Fortunately, there is a way of doing this that is both simple and general. It applies equally well to a wide variety of event-environment situations, and some straightforward observation and fact gathering is all that is necessary.

First, the *place* or location of the event itself is established. This can be done in terms of the whereabouts on a map whose lines and boundaries have been established by law (town, city, county, state). Or place can be described in terms of topography and physical dimensions: by a river, on a hill, two miles off a thru-way, etc. Both means of placing may be necessary.

A place with its people may be a community, or a neighborhood. On the other hand, it may be only a settlement whose people have so little in common they constitute neither a neighborhood nor a community. It is important to learn just what kind of place, socially and politically, one is dealing with. To this end, more questions must be investigated.

Having pegged the place, the next question is: What are the *resources* there upon which people have come to depend? Or the hopes and prospects which they hold dear? This part of environment description calls for some of the same knowledge that is generated by those who analyze biological and physical environments, the conditions and the resources of the earth, water, air, and climate. The student of social environment, however, is only concerned with these things to the extent that people have come to value them, use them, require them.

This extent and its consequences may both be considerable. People are inclined to fear that their way of life will be damaged or disrupted if the resource base is altered. Their fear is quite understandable.

Together, people and place and resources, each element acting on the others, produce *land uses*. A land use is literally the activity and the purpose to which a piece of land—a lot, an acreage, an acre—has been put by people. Uses are mapped and analyzed by many environmental scientists, businessmen, and public officials. Patterns and changes in land use are identified as basis for locating stores, highways, utilities, schools. On accurate predictions of land use trends—from agricultural to residential or from industrial to unused, for example—millions of dollars can be lost or made, whether as profits or tax revenues, not to mention political fortunes.

Like many things in society, land uses are never completely stable. And they may change very rapidly. It all depends on what is happening to the *people*—their numbers, their characteristics, their distribution, and to their economy and technology. Therefore the person assessing environmental impacts who wants to predict outcomes and weigh alternatives must know the land use patterns and population trends of one or more places. At the same time, he must figure the economic dimension of the social environment. (In this connection, note the attributes classified as regional economics and economics.)

So far in this brief account of the sociology technical specialty, we have introduced what teachers and research scientists call "human ecology." But that is only half of the social environment. Military managers must also assess the political realities of the place in which they would locate their projects and their activities. For engineers, especially, this seems to come hard. They are used to thinking and working with physical things and with tools from the physical sciences. "Software" considerations are not their forte. Nevertheless, engineering managers and decision makers today as never before perhaps must reckon with human cussedness and controversy. This is to say, they must anticipate and calculate the political reactions which their work is bound to produce. And they will engage in social engineering insofar as they act upon these considerations.

Because the essential ingredient of politics is power, and power is generated in *organizations* of people, the wise planner/manager will ask, "What are the organizations in this place, or with a stake in it, that I must reckon with?" State and local governments, business corporations, property owners associations, environmental groups, families—these are some of the kinds of organizations that may be present. How big are they? How powerful and influential are they? How is their *policy making* done—by what persons and what procedures? Have they enacted laws or regulations that could or should affect Army projects? Local and state government land use plans, zoning regulations, and building codes, are examples.

An organization may react favorably, unfavorably, or neutrally. The position an organization takes, as well as its capacity to generate broader support for its policy and to execute it successfully, will depend upon whether and how its members and its public believe their *quality of life* will be affected by the proposed new project.

Social environments come in three dimensions (see Figure 18 for attribute hierarchy): (1) human ecology, (2) collectivities, and (3) psychological. Human ecology is man in groups adapting by means of customs, laws, and technology to physical environment. Collectivities are a variety of groups. These range from complex business organizations like General Motors, and large associations like the Republican Party that are more or less organized, to small families, cliques, and clubs. The socio-psychological encompasses the attitudes, beliefs, and sentiments which are evoked in people as they cope with their several environments including the biophysical and economic. The three dimensions of the social environment are related one to the other. So also are social and nonsocial environments related. For example, what is called the resource base is detailed in the environments depicted by biophysical scientists; similarly with people or population characteristics and the socio-economic environment.

Each attribute listed is, in fact, a family or a nest of variables. So general is each item that the environmental analyst can easily go "down" to more and more particulars. For example, under land uses, "commercial" may need to be refined so as to differentiate wholesale and retail activities or, perhaps, financial and other service functions.

Empirical data can be generated for all attributes. Sometimes nonstatistical data will have to do. Indeed, such data may occasionally be prefer-

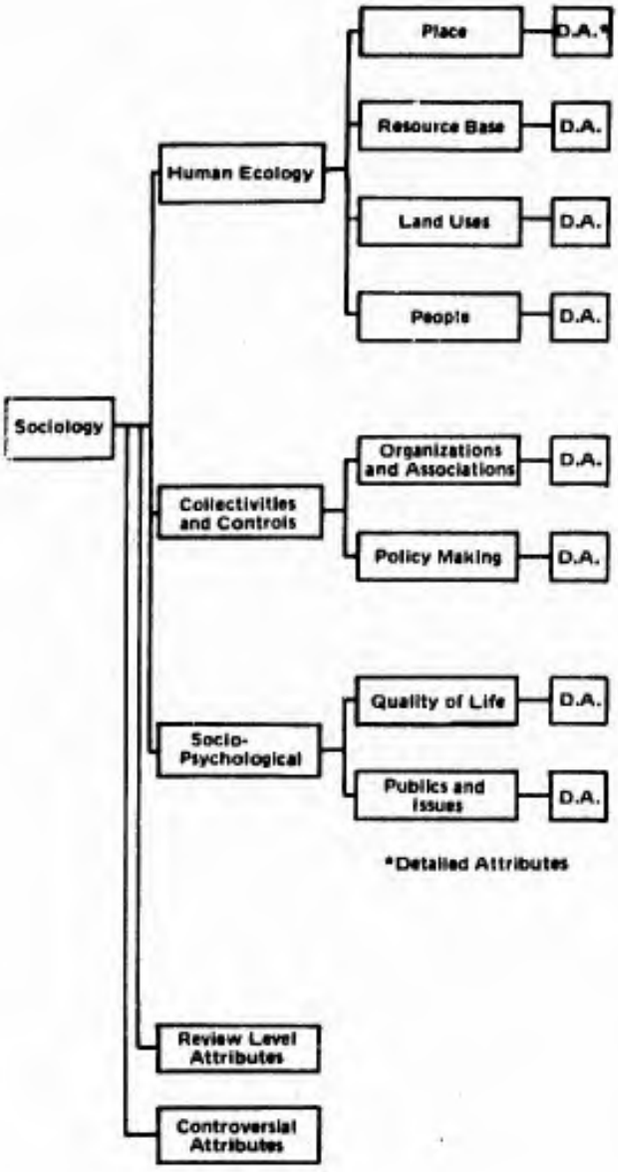


Figure 18. Attribute Hierarchy for Sociology

able because they offer more pointed or relevant measures—qualitative measures—than would available statistics. Data about collectivities, publics and related issues, and statistical material will tend to be more difficult to come by and often be less pertinent. However, these attributes are so important that they deserve the most careful attention even though the principal data may be qualitative and judgmental. The trick here is simply to find the best judges and analysts possible; those with maximum astuteness and objectivity on the locality or environment in question.

For all these attributes of social environment, the "flow" and "stock" principle that was noted in the case of the socio-economic environment also applies. Although there is no single input or through-put with social systems and environments, there are identifiable flows nevertheless that affect the inventory or stock of the attribute at any given time. In other words, though we have nothing as tidy as dollar flows for all social systems, there are beliefs, power, personality types, and categories of people that tend to move continuously through most social systems. And as they move or flow so do they affect the conditions and stocks of numerous attributes. The definitions and explanations follow.

Human ecology encompasses the interaction of place, resources, land uses, and people. The boundaries of *place*, which is to say the physical locality and area of likely impacts, are of two kinds. These are, first, political and legal such as the boundaries of municipalities, countries, and states. Second, are the natural boundaries, those imposed by landform, rivers, and lakes regardless of political-legal boundaries.

Resources are more fully treated by soil, water, and air specialists, but they also command attention as part of social environment precisely because humans, like other animals, depend on them, and because so much of social life is shaped by them. In what detail the resource base element of human ecology will need to be worked up will depend upon the place and the nature of the BAAPs that are involved.

Land uses in an ecological frame are the land-based activities of people, particularly the more durable and regularized activities. The *patterns* of land use, commonly differentiated in zonal or sectoral fashion and differing measurably in degrees of concentration and centralization, may be usefully mapped and compared historically. The six-part typology of zones or sectors of land use is a conventional ecological and land-planning breakdown. The terms refer to the predominant utilization of land areas within a larger place—a neighborhood, community, or region. There are standardized statistical techniques for sorting and classifying these and other uses.

The *relationships* between uses involve both process and condition, which vary and change with the flow of inputs such as more people or less people, more or less industrialization, and the like. The

descriptive terms (competition, invasion, etc.) will no doubt be familiar to biologists and other ecologists. Invasion and succession refer to the penetration of a given zone or sector by a different land use and the displacement or modification of the old use by the new. A white or residential zone goes black, an agricultural sector becomes a shopping center and trailer court, fields are followed by factories, for example. Competition stands for two or more uses that are seeking to gain a limited niche or ecological position. Competition is often symbiotic, each of the competitors meeting some need of the other. Conflict exists when one party seeks to destroy the other and rules of competition are disregarded. The outcome of conflict may be annihilation, but more likely it is accommodation (where party A makes way for and decides to get along with party B), or even cooperation (where the parties to a conflict actually work out their differences and pursue a common objective by mutually acceptable rules). There is adaption insofar as the relations between place, people, resource base, and land uses are in some state of balance that facilitates life and do not threaten human or societal survival.

People means people categorically, which is to say population. Three aspects of population are important environmental attributes. There is distribution, particularly as between residence and work. The movement of people and goods is included; for example, the journeys between places of residence and work, residence and school, residence and shopping. The transportation attributes are, of course, directly involved here.

Review Level Attributes. Places are the loci of human settlements and activities. They are also locations on a map that are differentiated and bounded for purposes of government into towns, cities, counties, states, and nations. Through changes in boundaries, places expand, contract, and lose or gain identities of their own. Souces of changes in boundaries are chiefly economic and political, reflecting changing numbers of people, economic shifts, and shifts in political power.

The condition and elements of earth, air, climate, and water of a place are its *resources*. They may be renewable resources such as crops, or nonrenewable resources such as minerals. The manner in which they are used or exploited is of great long-and short-term social significance.

Land uses are the ways in which identifiable land areas are utilized in the ecological system. They are the ways in which human activities and purposes have altered the basic physical and biological features of the earth. Some such changes are permanent and nonreversible, thus altering all future use of the area.

People is the human population that inhabits a given place, or the demographic component of an ecosystem. Since the population is the component of the ecosystem most responsible for altering the system, then any changes in its nature and size may have many ramifications.

The larger and more complex groups with designated missions and objectives are termed *organizations*. Their type and number depends upon the state of the local economy, its social and political history, and the local class structure. The education and income of the population affects action of organizations, as do any tradition of leadership and the quality of the communication apparatus in the community. Organizations are especially important because most actions and policy decisions are formulated and carried out by organizations.

Policy making varies in the extent of participation, scope of power held by groups or individuals, and effectiveness of influence of the policies adopted. It is, however, the process by which groups and organizations decide what their goals may be and how best to reach them. The decision makers influencing policy may have effects totally disproportionate with their absolute numbers if they are successful in influencing the policy making of important groups.

Quality of life is a general term for the various choices of life styles and amenities sought by the different groups within a population. They differ in personality needs and gratification, tastes, choices, and behavior from group to group. The subcultural groups definitely differ in patterns of land use and in consumption of goods and services.

The groups, or *publics*, which have come to agree on a point of view will find themselves on opposite sides of issues as a matter of course. When basic needs may be affected by the outcome of an issue, the publics may be large and militant. Similarly, and sometimes even more strongly, when amenity elements such as clean air and water, scenic vistas, or abundant wildlife seem to be threatened, the lines between groups may be clearly drawn and capable of influencing governmental action.

Examples of Typical Detailed Attributes.

RESIDENCE

A.

Residence is the distribution by household location of the nighttime population. It is commonly used by the Bureau of the Census for its work.

B.

Residential distribution varies by type of housing, i.e., single family, multiple family, attached and unattached, quality of housing, and composition of households.

C.

Sources of variation include housing market forces such as supply and demand, construction and financing activities, as well as such governmental policies as zoning regulations building codes and subdivision regulations.

D.

Residential distributions affect land use patterns and the demand for schools, recreation, shopping and civic and religious facilities. Residency affects also employment, politics, and ethnic relations.

DETAILED ATTRIBUTE WITHIN SOCIOLOGY
CONTRIBUTING TO HUMAN ECOLOGY

NET MIGRATION

A.

Net migration is the balance of immigration and emigration over a given time for a specific area. Immigration minus emigration equals net migration.

B.

Net migration is affected in its rate, numbers, and type of migrants and in its direction. Variation is a function of immigration and emigration characteristics for the area.

C.

Sources of variation include the motives of individuals, attraction or repulsion of the community or environment, economic or social circumstances, immigration policies, and other factors more difficult to predict.

D.

Effects on other attributes include those upon economy of the region, governmental change, and quality of life.

DETAILED ATTRIBUTE IN SOCIOLOGY
CONTRIBUTING TO SIZE OF THE POPULATION

SOCIAL CLASSES

A.

Populations are traditionally divided into from two to seven social classes based on various standards of wealth, education, occupation, family lineage, and other, less well-defined criteria. In some regions, class is a very important social factor.

B.

The number of classes in any one area is dependent on several factors, including historical tradition. Only very massive and often disastrous upheavals totally rearrange existing class structure, but smaller changes may come about due to industrialization, educational efforts, abnormally large emigrations or immigrations, and other factors tending to alter the status quo.

C.

Military construction may provide employment, temporary or permanent, which would allow some changes in income and status in the community. Large-scale troop training installations may also bring wealth into the economy of the area, resulting in new criteria of success. Off-base housing needs may also alter existing class needs and result in disruptive demands on local resources.

D.

The disruption of the status quo associated with construction and operation of facilities may lead to great redistribution of wealth in the local community. It may also lead eventually to changes in land use, reversal of traditional governmental policies on the local level, and creation of many diverse new interest groups.

DETAILED ATTRIBUTE WITHIN SOCIOLOGY
CONTRIBUTING TO COLLECTIVITIES AND CONTROLS

Controversial Attributes.

The *attitudes* or points of view of a collectivity or other group of persons are the prime causes of all controversies in all scientific disciplines. Since it is always reasonable to assume that the public in a region holds two or more opinions concerning a proposed activity, it is necessary to determine and delineate these positions.

The community potentially affected, or more importantly which feels it may be affected, by a proposed activity contains many diverse publics. Once the points of view present within the region are identified, it is necessary to determine the *size of the publics.* How many persons do they claim, and of what sort? Any group of over a few dozen committed persons may be very influential locally.

The *location of publics* with opinions or issues may be a geographic location, usually fairly near the area potentially affected, or it may be used to refer to where within the population a group may be found. In this sense, a group may be located within factory workers, racial groupings, or social classes. Sometimes it will be found that the public interested in an issue may be very diffuse geographically, but cohesive socially. An example of this might be fisherman using a particular lake during the summer.

Opinion makers are the individuals or groups that have the capacity to mobilize publics and to influence attitudes and opinions. Opinion makers process information, spot issues, articulate ideas and arguments, control the way issues or problems are defined, or control the media through which opinions gain expression and credibility. Some examples of opinion makers might be conservation clubs, religious leaders, news writers, and political figures.

Opinion making processes are the mechanism and procedures by which facts and ideas are disseminated to target audiences which may constitute publics. For example, the operation of government agencies, universities, research centers, political parties, schools, press, radio, and television may spread and form ideas and opinions on many issues.

Selected Ramification and Mitigation Procedures.

Construction — Ramifications: Site access, because it presumes a site already selected will almost certainly impact human ecology in respect to land uses and the distribution of people. Certainly it involves place or location. Whether resources or resource base for the social environment will be affected depends upon particulars of site which are presently unknown. Ecological impacts will predictably trigger involvement of collectives, psychological considerations, and probably evoke the response of publics to controversial issues.

Mitigations: Mitigation begins with adequate site planning. Adequate planning and site selection is prerequisite to either minimal or optimal impaction of social environments wherever construction is concerned.

The failures of site planning and careful site selection will perhaps first become apparent with the beginning of work on-site access. The political agencies and organizations in the social environment will be involved by law and by virtue of their responsibilities as representative agencies so far as a democratic process or civilian interest representation exist. Consultation on the part of the construction agency will be required at the minimum and no doubt negotiation, arbitration, and perhaps court action will follow.

As for the psychological dimension, the construction agency should have prepared or be ready to prepare a sensible and appealing case carefully grounded in facts and genuine probabilities that will have the effect of persuading or inducing acceptance by a sizable majority of the people in the area. Without further information no specification beyond this is possible. And we can only say that controversial issues are quite likely, around which publics of various sizes and dispositions will be formed. Again, social engineering will be critical here.

Preliminary Works — Ramifications: Here, as with the whole of the construction enterprise, for that matter, human ecology, place, and land uses as well as people are predictably affected. Correspondingly, a variety of organizations, most likely political and occupational, as well as policy making will become involved.

Mitigations: The agency which undertakes site selection, and plans site access, preliminary works and construction, will in all likelihood be expected to either be in compliance with local land use laws and regulations or to have secured a variance by due process. This is becoming increasingly likely throughout the United States as land planning and land use controls are enacted. In the past ten years, state agencies

have been promoting this for their own reasons as well as to be in compliance with federal grant and aid requirements of the Department of Housing and Urban Development, the Department of Transportation, the Department of Commerce, and other federal agencies. Commonplace regulation now includes zoning, green space reservations, and building codes. Desired or officially sanctioned land use patterns as well as amenities stand to be threatened or destroyed by new construction on any appreciable scale. Knowledge of these state and local regulations and the political agencies and social forces which they represent is essential for mitigation.

The first economic impact will also be made with site selection and site access and preparation activities. Here, too, political organizations such as planning and zoning commissions, boards of county commissioners, state planning agencies, and other federal agencies may be expected to enter the scene. Likewise, such occupational organizations as trade unions, agricultural and manufacturing corporations, and banks may also be involved insofar as the construction effort will affect local labor markets, and employment, and the skills profile of the labor force. The Army construction may be seen as competitive with local employers with damaging effects on wage rates, working conditions, and the like. Mitigation involves analysis of these things and the negotiation of an optimal adjustment with the Army making as good a case as possible in terms of local needs.

Demand for amenities should not be underestimated. Local people will want to know what the construction will look like, how much noise, air, water, and visual pollution they may expect in their midst, what beauty may be added, and whether their environmental lot will be improved on balance.

It is in connection with amenity elements especially that good site planning and architectural design are critical mitigation measures.

Utilities—Ramifications: Depending on the source from which utilities come, whether they are generated by the Army unit or drawn from civilian sources, the involvement of social environment attributes may be expected. Electricity, water, gas for heat, and so on, may be in short supply if the new construction produces an overload at any time. Waste on sewage disposal may also become socially implicated depending on the method of treatment and the whereabouts of landfills, dumps, or runoff as well as treatment plants.

Mitigations: Mitigation will require an analysis of local utilities in respect to their capacities as well as projected civilian needs in relation thereto. Consultation with local utility companies, major civilian industries, and builders are called for. The same principal of consultation and forecasting applies to the disposal and treatment of waste.

Finishing — Ramifications: Finishing is apt to be of social importance particularly where civilian populations who must live with it or will see the construction are sizable. It is conceivable that an Army construction located in a deserted area without public access can be finished and furbished so secretively there would be no reaction or response from a public. But even in such unlikely situations the amenity expectations and styles of life of civilian employees or nonprofessional soldiers, not to mention others, will need to be met at least at minimum levels.

Communications, like utilities, may affect local services in the area.

Mitigations: The principal mitigation here is good architectural design, interior decoration, and landscape planning.

As for communications, mitigation involves estimates of capacity and forecast of future needs where local telephone and mailing services are implicated.

Regional Economics.

Introductory Commentary. The complexity of the regional economic system in advanced societies like the United States requires an extensive classification system for its environmental attributes. The classification provides for the foreseeable need to specify impacts at different levels of detail in order to account for both the magnitude of various BAAPs and the varying complexity of the affected regional economics. Hence the classification provides for nested disaggregation or other partitioning plans of the major attributes to any desirable level. The detailed levels indicated are only suggested at this time, since some may have to be further classified.

The approach rests on social accounting methods and development of various social indicators. Specifically, an impact of an activity like a BAAP will affect persons, their property, and the natural environment. The first two pertain directly to the socio-economic system, while the third is only partially related. Further, all socio-economic phenomena can be classified into "flow" and

"stock" variables. For example, of the total income flow of an individual, a part can be allocated to consumption and another to investment. The part which is invested adds to the assets (a stock variable) of this individual.

The classification of the socio-economic environment consists of the following major classes which are shown in Figure 19.

1. Population;
2. Employment;
3. Labor force;
4. Human capital;
5. Income and output; and
6. Assets.

To these, two complementary major classes having unique spatial dimensions are added:

7. Transportation and
8. Land use.

Finally, a residual classification is added, to include those social indicators not present in the above system:

9. Selected indicators.

Of these nine major classes, only the first five are described further below. The human capital category described here contains a certain overlap with the social environment, as discussed in the previous section.

Each of the major environmental classes can further be classified into two-, three- and more digit classifications.

Owing to the nesting of classes shown further below, it is possible to extend the classification to obtain more detailed breakdown. For example: 2.0 Employment, is further classified into 2.1 Employment by Industry, where the major industry divisions of the Standard Industrial Classification (SIC) Code are used. Hence 2.1.4 Manufacturing Division D. SIC 19-39 can further be classified to obtain 2.1.4.11 Electrical Machinery Equipment and Supplies (SIC 36) and if necessary into 2.1.4.11.01 Electrical Measuring Instruments and Test Equipment (SIC 3611). At times this fine disaggregation may be necessary in order, for example, to identify the contribution of each industry to the generation of pollution.*

A presentation of typical flow (regional economic) and stock (community assets) follows. The stock attributes are presented first.

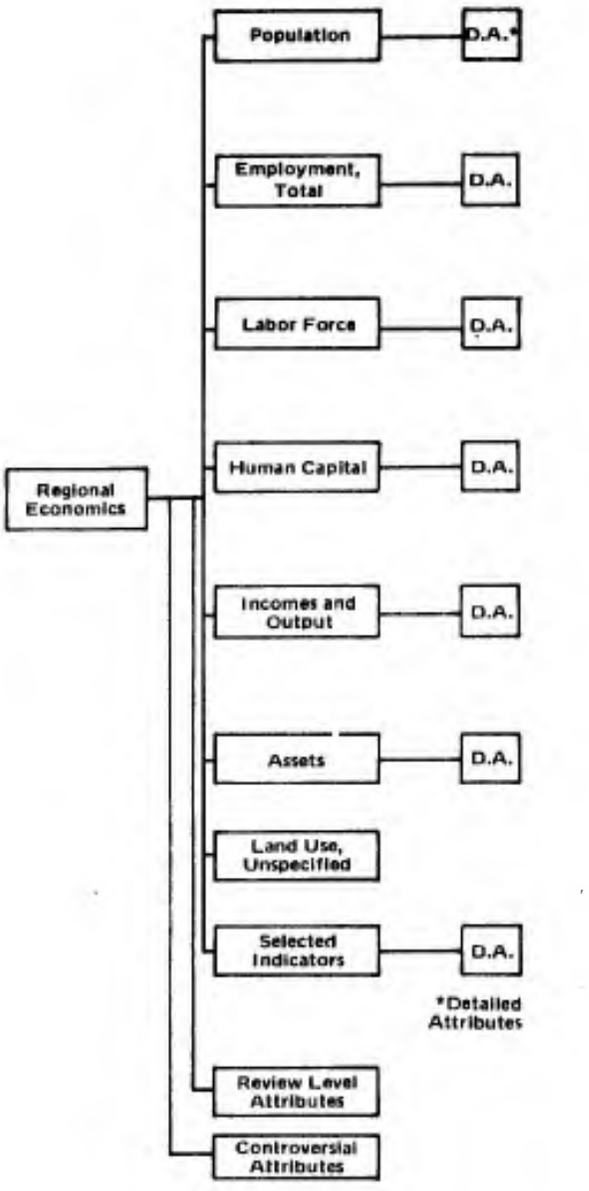


Figure 19. Attribute Hierarchy for Regional Economics

* For example, it was estimated that leather tanning and finishing (SIC 3111) discharges 15 times as much poundage of BOD per dollar output than personal leather goods (SIC 3172). See E. Romanoff, "The Boston Region Leather Industries and Sub-Industries; Their Interdependence, Water Utilization and Space Use," *Technical Paper No. 8*, Regional Science Research Center, Cambridge, Massachusetts, December 1969.

Examples of Typical Detailed Attributes.

PRIVATE SECTOR ASSETS UTILIZED IN MANUFACTURING

A.

Private sector assets utilized in manufacturing are land, equipment, and inventories engaged in the mechanical or chemical transformation of materials or substances into new products. These assest are usually described as plants, factories, or mills utilizing power-driven machinery and materials-handling equipment.

B.

The value of private sector assets utilized in manufacturing will be affected by changes in the use of manufacturing assets or by changes in the quantity of supply of manufacturing assets. An example of the changes of the use of manufacturing assets resulting from Army activities would be changes in the demands for goods produced by a manufacturing process and utilized or consumed by military activities. If a base were to reduce or to increase its military activities, one would expect a change in the value of the manufacturing assets which supply inputs to that particular activity. An example of the change in the quantity of manufacturing assets for a given community would be provided by the case where a military establishment undertakes the manufacturing process. In this case, new quantities of the manufacturing asset would be generated within the military and would not require utilization of the asset outside the military establishment. As a result, the value of the manufacturing establishment outside the military would be reduced.

C.

The changes in military manufacturing activity will result in changes in the value of private sector manufacturing assets. The changes in military activity which utilize production from manufacturing assets will also change the value of the manufacturing assets.

D.

Changes in either the quantity or in the value of manufacturing assets will have the effect of changing production, incomes, and employment in the relevant manufacturing category. In addition, of course, the changes in manufacturing activity will probably also have the effect of increasing or decreasing the quantity of effluent discharged into the environment and thus will affect the environment in a fashion exactly similar to the effects that occur exclusive of military activity.

REGIONAL ECONOMICS ATTRIBUTE
RELATED TO PRIVATE SECTOR ASSETS

AGRICULTURAL, FORESTRIES, AND FISHERIES ASSETS

A.

Assets in this category include the tangible land and natural resources, structures, durable goods, and inventories for establishments engaged in agricultural production, forestry, commercial fishing, hunting and trapping, and related services.

B.

Assets are affected either directly by changing physical availability or indirectly by changing demand or the price.

C.

Agricultural assets would be changed by changing the availability of land either through Army sale or acquisition. Changes in agricultural procurement policy would affect the value of resources devoted to agricultural production. Army activities which would affect local crop yields would affect agricultural assets. Forestry assets would be affected by Army activities which change either the available forestry assets or the flow of forestry-related products. Fishery assets would be changed by Army activities which affected the availability of the resources necessary to undertake fishing--fish, boats, men, facilities. Any activity which affects the flow of resources into or out of fishery activities could change fishery assets.

D.

Changes in agricultural, forestry, and fishery assets may change the relative importance of this sector of the local economy. This might have an impact on employment, incomes, and/or production in this and other sectors.

REGIONAL ECONOMICS ATTRIBUTE
RELATED TO PUBLIC SECTOR ASSETS

PUBLIC AND PRIVATE ASSETS NOT ELSEWHERE CLASSIFIED

A.

This category of public and private assets is provided as a catch-all for assets which may not have been identified in other areas. The major categories of unclassified assets are:

6.3.1 Archeological Sites
6.3.2 Historical Sites
6.3.3 Unique Cityscapes
6.3.4 Unique Landscapes
6.3.5 Other Unclassified Public Assets

B.

The value of these assets will be affected primarily by changes in the way in which they are used. In general, it is not possible to alter the supply or the quantity of these types of assets.

C.

Any Army activity which prevents the utilization of the public and private assets described and considered under this section would affect the value of these assets to the community. For example, military base activities which prevent access to historical sites or which, under some circumstances, may destroy certain archeological sites would be considered detrimental to the community to the extent that it reduces the value of these assets to the community. Equally as important is the possibility that Army activities will provide new routes of access to historical sites and provide new access to specific archeological sites. The potential effect of Army activities on the cityscapes and landscapes in the areas near the Army establishment.

D.

Changes in the value of public sector and private sector assets within this category will have their primary effect on the social well-being of individuals in the surrounding community. In general, one would not expect them to have effects on employment, production, or incomes as a result of changes in the value of these assets.

REGIONAL ECONOMICS ATTRIBUTE
RELATED TO PUBLIC AND PRIVATE SECTOR ASSETS

PUBLIC CONSTRUCTION ASSETS

A.

Public sector construction assets consist of all land, structures, and certain equipment used in the construction process. Construction implies new work, additions, alterations, and repairs. This category covers assets utilized in three activities: building construction, other construction, and special construction. The construction assets category applies to all federal, state, and local land, structures, and equipment owned by the public agency and used for construction purposes. State highway construction or repair activities would fall into this category. The equipment used would be an example of a public construction asset.

B.

These assets are affected by any activities which change their depreciation rates. They are affected by activities which change the availability of the asset.

C.

Changed usage of the facilities maintained or built by the construction activity will affect future use and thus the value of the construction asset. Army use of public roads may require increased expenditures to maintain them. Changed demands on water and sewer systems may impose changed demands on extension and repair systems, thus changing the value of the equipment, land, and structures.

D.

Changes in public construction assets may have an effect on employment, production, and incomes.

REGIONAL ECONOMICS ATTRIBUTE
RELATED TO PUBLIC SECTOR ASSETS

POPULATION

A.

In accordance with census practice a person is counted as an inhabitant of his usual place of residence, which is generally construed to mean the place where he lives and sleeps most of the time. Persons without a usual place of residence are counted at their place of enumeration.

Members of the Armed Forces living on military installations are counted as residents of the area in which they are located. Members of Armed Forces not living on a military installation are counted as residents of the area in which they are living. Crews of U.S. Navy vessels are counted as residents of the home port of a particular vessel, but crews of vessels deployed to the overseas fleet are not included in the population of any state. Similar rules apply to members of Armed Forces families and crews of U.S. merchant marine vessels. College students are counted as residents of the area in which they are living while attending college. Inmates of institutions who ordinarily live there for a considerable period of time are counted as residents of the area where this institution is located; on the other hand, patients of general hospitals, who ordinarily remain for short periods, are counted at their homes.

Transient populations which are excluded from census reports are all those who live for a short period of time not at their place of residence, e.g., hotels, camping sites, and other facilities, and who visit an area for purposes of recreation, tourism, and vacationing, for business purposes, for personal reasons, or for other reasons.

B.

Changes in population may result from (1) the vital process (i.e., births and deaths) and (2) migration (i.e., immigration into and emigration from an area).

C.

Any activity or program which directly or indirectly affects the vital process or migration will cause a change in an area's population. Generally, the smaller the area the more important becomes the effect of migration. The composition of migrants will affect the composition of the local population.

D.

Changes in populations will tend to affect directly or indirectly *all* of the environmental attributes.

Population is further subdivided into three:

1.1 Population in households, grouped quarters and transients
1.2 Resident population by age
3. Other population classifications

Their characteristics are briefly noted below:

1.1 Population in Households, Grouped Quarters, and Transients

Total area population as noted above, consists of households and those in grouped quarters, as given in the U.S. Census of the Population. The population in grouped quarters is further subdivided to separately identify those living on military installations and briefly identified as living in military barracks even though family housing (households) is included in that class (1.1.2.)* Their socio-economic behavior may not be typical of the civilian population in an area.

The last category, transient population, is added in order to separately identify this population associated with BAAP effects, whose economic behavior usually differs from the local population (e.g. in consumption patterns) and who may compete for transient accommodations in a region (e.g., in hotels, motels, rooming houses, and other lodging places--2.1.8.1 and 5.2.8.2).

*The numbers in parentheses refer to environmental attributes for this technical area of specialty. See EICS output.

1.2 Resident Population by Age

The classification by age is particularly useful to identify changes in the population characteristics resulting from a BAAP. The most important groups are those of school age (1.2.2 and 1.2.3) owing to the effects BAAPs may have on the local school system and the associated compensation to be paid to these schools. Other classes complete the age classification and provide for a yardstick to assess demographic changes in the population. In some situations a more detailed classification may be necessary, further cross-classified by sex.

1.3 Other Population Classifications

This open category provides for those demographic attributes which may be particularly important in specific situations (e.g., classification by ethnic orgin, by race, and cross-classifications).

REGIONAL ECONOMICS ATTRIBUTES RELATED TO POPULATION

EMPLOYMENT

A.

This class contains all full-time and part-time employees in a region, on the payroll of operating establishments, or other forms of organization, who worked or received pay for any part of a specified period. Included are persons on paid sick leave, paid holidays, and paid vacations during the pay period. Excluded are members of the Armed Forces and pensioners carried on active rolls but not working during the period. Officers of corporations are included as employees; proprietors and partners, however, are excluded from total.

B.

Generally, changes in employment result from changes in level of economic activity. That is, with increased level of output generally more employees may be required. However, improved productivity may modify the demands for employment, usually requiring a lesser number of employees to produce the same level of output.

C.

The causes that may affect production, and hence employment, may be varied. Generally, two main effects may be distinguished: (1) direct effects, where a BAAP requires the services of a particular industry (e.g., construction of barracks) thus causing the employment of a specified number of employees by the construction industry, and (2) indirect effects, of those employed by industries supplying the construction industry (for building the barracks) as, for example, building material industries and by the industries supplying the building materials industries, and the suppliers to the suppliers, and so on. Here a multiplier effect tends to operate which specifies the total direct and indirect level of output resulting from the direct demand for a given output. These multipliers, for output and for employment, are unique to industries and regions. Generally, the more advanced the economy and the larger the region, the larger the multiplier will tend to be.

For example, a recent study of the impact of highway construction on the Massachusetts economy indicated that for $100 million of investment in highways, 3830 man-years of employment will be directly required by the relevant construction industries (i.e., highway and street construction, SIC 1611, and heavy construction, SIC 1621). A total of 8240 man-years of employment were calculated, representing an employment multiplier of 2.25.[59] Highway construction may be a legitimate BAAP.

D.

The resulting employment can affect the labor force and contribute to regional growth in population where the relationship between employment and population is given by labor participation rates, particularly if unemployment levels are low and the effect is of long duration. Otherwise, interregional commutation or seasonal migration of workers to key affected industries (as construction, in the above example) may take place.

Environmental repercussions will also take place. Increase in output and traffic flow will add to air emission (note, cement plants are notorious air polluters). Similarly, increases in waterborne wastes and solid wastes may be expected.

Employment is further classified into three classes:

2.1 Employment by industry
2.2 Employment by residence
2.3 Employment by minority group

The classification of employment by industry is for obvious reasons, and follows the SIC Code by which all government statistics are organized. The classification by residence is included to measure interregional

[59] E. Romanoff, *Impact of Highway Construction on the Massachusetts Economy*, Discussion Paper No. 72-1 (Regional Science Research Center, 1972).

commuting patterns and, if necessary, the class titled Employees residing locally (2.2.1) can further be disaggregated to identify residence by subareas of a region. The classification by minority group pertains to the distributional effect a BAAP may have among minority groups. The increasing recognition of the importance of economic welfare questions suggests that this attribute may gain in importance in future years.

REGIONAL ECONOMICS ATTRIBUTES
RELATED TO EMPLOYMENT

INCOME AND OUTPUT

A.

Broadly defined, the income category records the income of population or of consuming units in a region, while output records the income or producing units in a region.

Income of a population, consisting of families and unrelated individuals, may be earned from wages and salary income, or from other sources of income.

Wages and salary income includes money earnings received for work performed as an employee during a specified period. It includes wages, salary, pay from the Armed Forces, commissions, tips, place-work payment, and cash bonuses earned.

Other income include self-employed income, social security and retirement income, public assistance income and other income from welfare payments, income from property such as interest dividends and net income from property rentals. Also included are such sources of income as annuities, unemployment insurance benefits, alimony, and net gambling gains.

Output is broadly defined as the selling value of goods and services of producing units. Owing to difficulties in valuation of output for some sectors of the economy, different measures may be employed. Thus, for manufacturing units, output is generally measured in terms of value of shipments, for the trade sectors in terms of sales, for service sectors in terms of gross receipts.

Another commonly used measure is value added which represents total output less cost of materials, fuels, and other material-related items purchased from others. Here again different valuations are sometimes employed, resulting also in measures of gross and net value added. For our purpose gross value added as reported by the U.S. Census is appropriate.

B.

Changes in income and output may result from (1) changes in the quantity of work performed or products sold, or (2) changes in the price of labor (i.e., wage rate) or other income (e.g., interest rate), or in changes in the price of output.

C.

Changes in output and income result from changes in the demand for the output of products and services, and in the demand for labor and other sources of income. To the extent that any BAAP will cause a change in the Army's direct or indirect pattern of purchases in an area, or in its direct and indirect payroll expenditures, income and output will change.

D.

Changes in income and output will affect employment and labor force, population, and transportation. They may also affect the stock attributes of human capital and assets, and hence land use. Changes in income and output will affect the discharge of residuals (wastes) into the environment thus also affecting the biophysical attributes.

REGIONAL ECONOMICS ATTRIBUTES
RELATED TO INCOMES AND OUTPUT

Review Level Attributes. Discussion of assets (stock) and regional economic attributes (flow) at the review level required a three fold breakdown. Assets are described as those whose value tended to remain relatively fixed over time, such as *land and natural resources*, or those whose value could change with a fluctuating economy, such as *structures, equipment, and inventories.* Attributes of the regional economy are categorized as a generalization of the detailed attributes *total employment, total income, total output*, with the new attributes of *overall effects on the local community* and *aggregate economic measurements* added. A discussion of all review level attributes follows. Two attributes of community assets will be described first, followed by regional economics.

The change in *value of land and natural resources* is an indicator of change in the stock or quantity of certain resources, for example, minerals, which are used in the conduct of man's social and economic activities. The category of land and natural resources indicates relatively fixed stocks of resources which are not readily replenished by additional economic activities. For example, coal is a natural resource which, once mined and utilized as coal, cannot be replaced. This category of economic change is important to decision makers because the extent to which the quantity of irreplaceable resources is changed will become increasingly more controversial as real or feared shortages in these resources develop.

The *value of structures, equipment, and inventory* is an indicator of change in the stock or quantity of resources such as buildings, trucks, or furniture which are used in the conduct of man's social and economic activities. The category of structures, equipment, and inventory indicates capitol stocks which are replaceable by additional economic activity. For example, it is possible to reconstruct a building elsewhere if it were rendered useless by project activity. If a project were to make some vehicles obsolete, replacement with other newer alternatives would be possible.

The *total employment effect* relates to all full-time and part-time employees in a region, on the payroll of operating establishments, or other forms of organization, who worked or received pay for any part of a specified period. Included are persons on paid sick leave, paid holidays, and paid vacations during the pay period. Excluded are members of the Armed Forces and pensioners carried on active rolls but not working during the period. Officers of corporations are included as employees; proprietors and partners, however, are excluded from the total.

Total employment can be affected by direct demand for services to perform a specified task or by indirect demand as secondary and tertiary activities increase their level of operation due to the respending of money within the region.

Total employment would include employment by (1) industry, (2) residence, and (3) ethnic group.

Generally speaking, *total income* for a region refers to the income of people, factories, services, etc., in the region. This income normally comes from salaries and wages paid to the individuals in return for services performed. Included in this attribute are incomes from social security, retirement, public assistance, welfare, interests, dividends, and net income from property rental.

Incomes are most easily affected by changes in purchasing patterns in the region. The magnitude of potential affects from the Army is related to the Army's relative economic size within the region.

Output can be defined as the income of the producing units in the region. Indicators of regional output are: (1) value added to a product as a result of a manufacturing process, (2) gross receipts for service industries, (3) total sales from the trade sector, and (4) values of shipments.

Output can be affected by direct and indirect expenditure changes.

The *overall effects on the local community and public facilities operation* attribute is a synthesis of the population, human resources and community facilities attributes. As such, it is a general impact attribute dealing with potential effects on local housing, schools, hospitals, and local government operations. Army activities involving mission changes could most readily produce a measurable effect on this attribute.

Topics such as aggregate employment multipliers, aggregate income multipliers, and aggregate output multipliers are other important effects. These are complex attributes normally associated with specific operation changes. They can be noted at the review level. Normally, however, assessment of their changes can only be measured by professionals, usually in case specific studies.

Controversial Attributes. Controversies have

many facets. When programs affecting a regional economy are proposed, controversies can usually be expected. They tend to range over the expected repercussions of such proposals. Involved are questions pertaining to the expected change from the status quo, and from the perceived change expected by social progress. Both goals or yardsticks, the status quo and the expected social progress, may be adhered to by the region's residents, generally with one dominating. These yardsticks may be differently applied and with various intensities to different attributes and their groupings, representing the particular interests held by each of the various groups in a community. Generally, the larger and more heterogenous the community, the larger the divergence between these yardsticks. Controversy, then, can even be double edged, with some alleging "too much" and others "not enough."

Uncertainty of outcome, then, pertains to the distributional effects of a program, with each interest group guarding its interests. The effects considered are not limited to traditional economic aspects but include other spheres of impact as well (e.g., water pollution). These interest groups may be industries or organizations, income groups, ethnic and minority groups, occupational groups, some age groups, neighborhoods, and other groupings of spatial association (e.g., towns, counties). Within these multiudes of potential controversies, generally only some emerge in each case as dominating all others.

Again, a dichotomous classification between assets and regional economics was employed. First, controversial attributes of community assets are discussed, then the regional economics area.

An examination of the impacted asset attributes suggests that there are several potential categories where controversy regarding military impact on these attributes has occurred in the past. Controversial impacts can be identified for virtually all of the attributes, but some of the attributes could provide potential for more controversy than others. Transportation and housing is viewed as a combination of private and public sector assets and therefore suitable as an agglomerated controversial attribute.

Within the category of private sector production assets, the greatest potential controversy arises with regard to *private manufacturing assets* and *private wholesale and retail trade assets.* To the extent that military activities compete directly with private sector manufacturing, it has a negative impact on the value of production from the private manufacturing sector and this has a negative impact on the value of private assets. To the extent that military activities on a base, usually in the form of post exchange or commissary facilities, compete with private sector wholesale and retail trade industry in the local community, the military activity has a negative impact. Both military munitions manufacturing and military post exchange and commissary facilities are recognized as competition to production in the private sector.

The major public sector assets that would arouse local and/or community controversy would be *transportation, communication, electric, gas,* and *sanitary services,* and *private households.* Mission changes by military bases frequently impose significant new burdens on the transportation, communication, electric, gas, and sanitary services in the given community. While other public sector assets may be affected by changes in the military activity, public utilities are the ones most likely to receive the greatest impact.

The effects of military mission changes or other changes in activity at a given Army installation have major impacts on the local property values surrounding the base. Changes in directives resulting in changes in the number of military families living on base (or off base) may have dramatic effects on the value of private household assets.

The effects of Army activity on *archeological* and *historical sites,* and *unique landscapes* and *cityscapes* have the potential for more controversy than any other category of assets. If the Army were to disturb or prevent access to an archeological site or historical site, the chances of arousing local community opposition to the Army activity are quite high. If the Army activities were to affect unique cityscapes or landscapes in a given community, there is significant impetus for local intervention to impede the Army activity.

If it were necessary to specifically identify attributes for red-flagging within this specialty the attributes of *total employment, unemployment,* and *income of populations* would most likely be chosen. These represent controversial attributes.

Most important, programs generating income in a region are less likely to be objected to than those which reduce the flow of local income.

The larger the magnitude of a program, the larger its impact, and the larger may be the deviation from an expected yardstick. Thus, for example, a reduction in personnel strength will not cause as large a controversy as the downright objection to the closing of a facility.

Another important source of controversy pertains to stability of programs. It implies that cyclical operations, involving both increases and decreases in magnitude, must be phased to fit local conditions.

The length of a program must also be considered. Short-term programs involve residual effects at the termination of an impact, and deal with the ability of the system to revert to its status quo, or change toward the expected future social progress. Long-term and permanent programs (like construction) raise questions of alternative uses and alternative costs. They involve consideration of economic efficiency as measured by low alternative cost and differ from engineering efficiency measured by physical standards. When controversy prevails there is often a tendency to overemphasize engineering aspects at the expense of economic aspects of the problem.

Response to programs in a region suggest that locally they are not viewed as independent of each other, indicating that controversial inertia developed for one program or aspect of a program may spill into another aspect of the same program, or into another program. Conversely, one program may mitigate the effects of another.

This comprehensive view of balancing effects of diverse programs suggests an overall approach to reduce but not eliminate controversies. That is to say, the overall impact will not make anybody worse off, and will at least to some extent make some groups better off.

A gauge to reading the attitude of local communities with respect to particular programs is provided by the attribute friendliness and related social norms. It can provide, in combination with the rest of the impact analysis, for the identification of sources of controversy.

Selected Ramification Remarks and Mitigation Procedures. For this technical specialty ramification remarks and mitigation procedures were developed at the subprogram level or higher. That is to say, instead of rating impacts of specific construction activities, such as clearing, the construction of facilities in general was evaluated.

Ramification Remarks for Construction Functional Area: Some large construction programs which are undertaken over a long period of time require special attention. Their impact is likely to alter the structure of the regional economy and the demand placed on various community facilities and services. Large construction projects and large mission changes fall into this category. As a consequence of these programs, regions may decline or grow in population, or change their economic orientation and level of public services. These long-term effects dealing with aspects of regional growth and development are contrasted with short-term effects of generally small size programs of short duration. In the latter case, once the program is over the effects almost disappear and barely affect population size, economic structure, or level of public services.

The attributes which tend to record long-term effects are particularly those pertaining to population size, educational services, medical and other health services, local and state government, and employment and output of the affected producing and service sectors. To those one must add the demand for housing and other community facilities and change in assets of producing and service sectors.

These large and long-term programs require a much more detailed and careful analysis than do ordinary programs. Note the definitions of "large" and "long-term" have deliberately been avoided, for they will be modified by the size and characteristics of a region and its economic performance, and by prevailing national economic conditions. As a very crude guide, long-term programs may be those lasting more than two to five years. Similarly, large programs may be those which affect the productive capacity of sectors, and have an aggregate employment impact accounting for more than 10 to 15 percent of the regional civilian labor force. Another way to look at programs having long-term effects is by considering a period long enough for labor to justify migration, together with their families, to the impacted region.

Small construction BAAPs may be excluded from individual measurement since their impact on a regional economy is small and insignificant. Small BAAPs have the following characteristics (subject to further testing):

1. They are no larger than an average com-

parable civilian activity, many of which are undertaken every year in each region; and

2. Errors in measurement may obscure unique impact typical to a BAAP.

These small BAAPs should be aggregated by program, and the programs by region, to obtain measures of aggregate impact.

The magnitude of the construction BAAP will be modified in part by the size and characteristics of the region affected. Preliminary (crude) estimates, subject to later revision, suggest the following threshold for large construction projects:

1. Two million dollars and over of construction put in place per year—for a small region with a rural economy and an urban trade center; and

2. Five million dollars and over of construction put in place per year—for projects located in proximity to metropolitan areas.

Increase in the amount of migrating labor for at least the length of the construction BAAP will cause an increase in regional population and thus in local consumption triggering, in turn, increases in level of production of a different set of industries. These effects, however, are excluded from measurement of construction BAAPs and require separate treatment. They may be abstracted from relevant BAAPs in mission change programs.

"Small" construction projects, which may be excluded from evaluation, are defined (subject to further testing) to consist of those of less than $500,000.*

Mitigation Procedures for Construction Functional Area: Generally construction is desired since the effects are considered beneficial. However, in some cases, the accelerated pace of construction by the addition of construction BAAPs to the civilian regional construction pace may add inflationary pressures to a regional economy by the stimulation of higher prices in industries operating near their capacity, and the tendency to expand capacity in bottleneck industries. These affected industries may command higher prices for their products and pay higher wage rates. The repercussions of these price changes in some industries will affect the performance of other industries and consequently the growth pattern of the affected region.

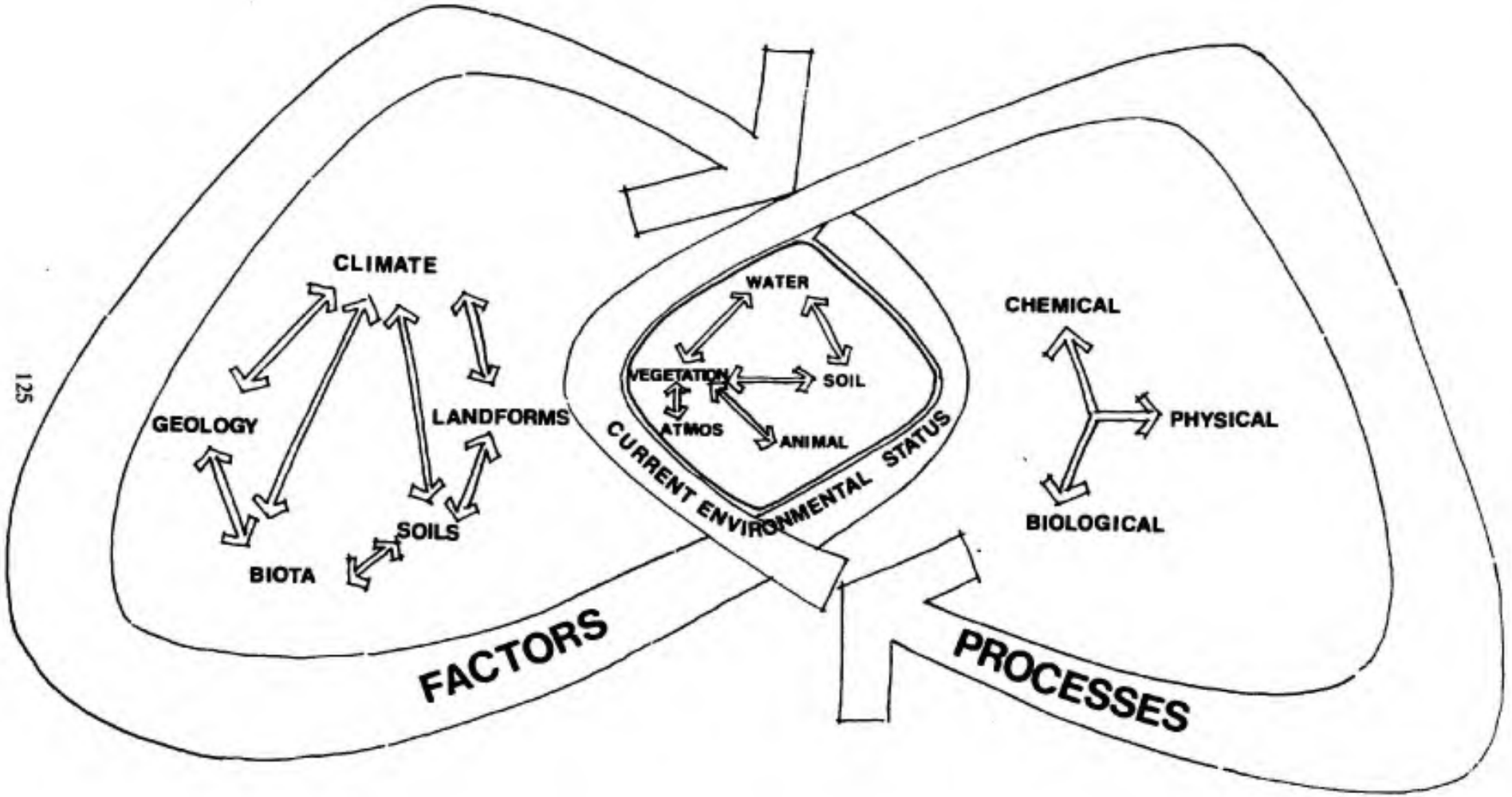
Mitigation of these effects may be undertaken by scheduling construction BAAPs to fit into the pace of regional construction, in order not to create undue pressure on the production capacity of construction and construction-related industries. These mitigation efforts may, however, be in conflict with the ultimate objectives of the construction BAAPs, for in the case of large projects it may require the lengthening of the construction period by several years. For small construction projects, possible seasonal adjustment can be undertaken thus reducing inflationary pressures to some degree, and possibly realizing some savings in construction cost.

Earth Science.

Introductory Commentary. The earth science attributes of the physical environment are of immense importance to the biotic life of the earth. Although treated separately for ease of discusion, as shown in Figure 20, the attributes are interlocking elements of the physical environment supersystem. For example, one attribute, the soil that mantles the land surface, is the sole means of support for virtually all terrestrial life. As this layer is depleted by improper use so is the buffer between nourishment and starvation destroyed. However, the ability of soil to support life varies from place to place according to the nature of the local climate, the surface configuration of the land, the kind of bedrock, and even the type of vegetation cover. At the same time the vulnerability of soil to destruction through mismanagement will also vary as these factors change. Cultivated soils on slopes greater than 6 percent or those that developed on limestone are prone to erosion, soils in arid climates are sensitive to poisoning by excessive salt, whereas those in the tropics may quickly lose their plant nutrients by exposure to the abundant rainfall of those areas.

Although other attributes might have been chosen, soil serves well as an example of an interface between the three great systems that comprise the earth sciences: the lithosphere, the atmosphere, and the hydrosphere. The biosphere also operates in this interface, but it is usually considered to comprise the life sciences. For purposes of this discussion the lithosphere consists of the various attributes of landforms (slope, elevation, etc.), landform constituent materials (substratum), and the weathered layer or

*A $500,000 project requiring the construction of a building represents the construction of 15,000 to 25,000 sq ft equivalent to a small suburban office building, medical building, or a row of stores.



EARTH SCIENCE INTERFACES

soil regolith; in the case of the atmosphere the main elements are the attributes that describe its state of temperature, moisture and motion—or in a word, climate; with regard to the hydrosphere the principal concern will be with water flowing over the land surface in the form of sheet wash and streams.

On first appraisal, it seems evident that the *earth science attributes* could be divided into two broad sections—those of landforms and those of climate. However, only a very few of the descriptive attributes of landform and climate will be affected by Army activities. For example, the landform attributes of elevation and slope can be only slightly modified as is the case, say, for the seasonal distribution of temperature and rainfall. On the other hand, climate attributes can combine with those of landform to profoundly affect the consequence of Army actions. For example, the removal of vegetation from steep slopes in areas of high rainfall will result in intense soil erosion and the subsequent clogging of stream channels. Adverse effects on man and aquatic life would likely follow. Since the descriptive attributes of landform and climate define precisely the setting of an activity, a more satisfactory division of the earth science attributes would be to include those of a descriptive nature (that interact to affect the results of Army actions) referred to as *site attributes* and those of a dynamic nature (that can be directly modified by Army action) referred to as *process attributes*. Owing to the dichotomous relationship between BAAPs and the earth science site attributes, descriptors for site attributes were modified slightly. That is to say, under Section B, "How the attribute can be affected by Army activities," two alternatives, B and B^1, were developed. The B alternative, or traditional descriptor, describes how an Army activity affected that attribute. The B^1 alternative describes how the site attribute could affect the Army activity. For example, continual usage of a hilly area for tracked vehicle maneuvers could reduce the altitude of some of the hills. This is the B alternative. However, the more likely impact, the B^1 alternative, would be that the hilly area would increase fuel consumption for the vehicles and lead to accelerated erosion due to the disturbance of the area's groundcover by the tracks.

This dichotomous descriptor package was used only for the earth science technical specialty. The other areas were developed in keeping with the already discussed descriptor format. The earth science hierarchy is shown in Figure 20.

Climate profoundly influences, the nature of site attributes such as soils and vegetation. Soil trafficability, to a substantial degree, is the result of the interaction of rainfall and temperature with the local rock types. The rate of soil erosion, other things being equal, will depend upon the amount and intensity of rainfall. The details of the site climate must be known before an adequate environmental impact assessment can be made.

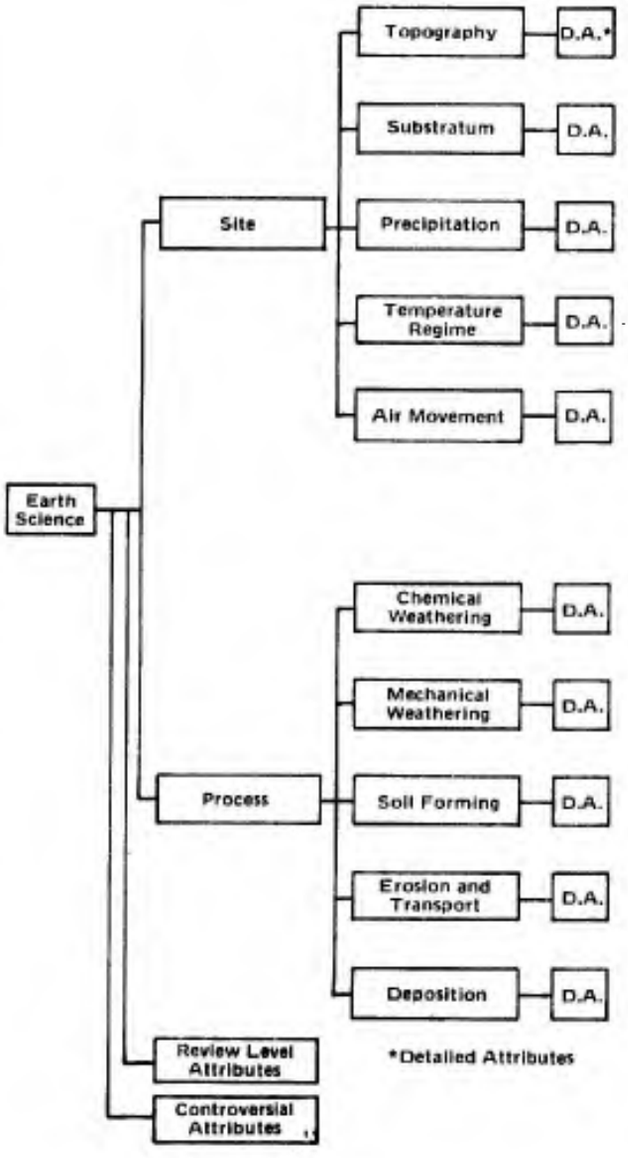


Figure 20. Attribute Hierarchy for Earth Science

Climates are commonly identified and described by the total annual amount of precipitation and its seasonal distribution and by temperature and its seasonal distribution. Climatic types may be described as warm-humid, cool-humid, cool with summer droughts, arid, semi arid, and so on. There are additional descriptive elements of climate that are important in causing substantial differences within any one climatic type. Some of these include: probability of maximum rainfall intensity, probability of drought, length of growing season, wind intensity, and the kind and frequency of storms. Others are shown on the list of earth science attributes.

The user of the environment impact assessment system should be aware of the local landform type and its constituent materials. This information will enable him to more quickly evaluate the potential hazards of his activity upon the local physical environment. For example, slope erosion problems should be slight in plains areas with low relief. Areas underlain by limestone must be treated everywhere with caution with respect to groundwater pollution, etc.

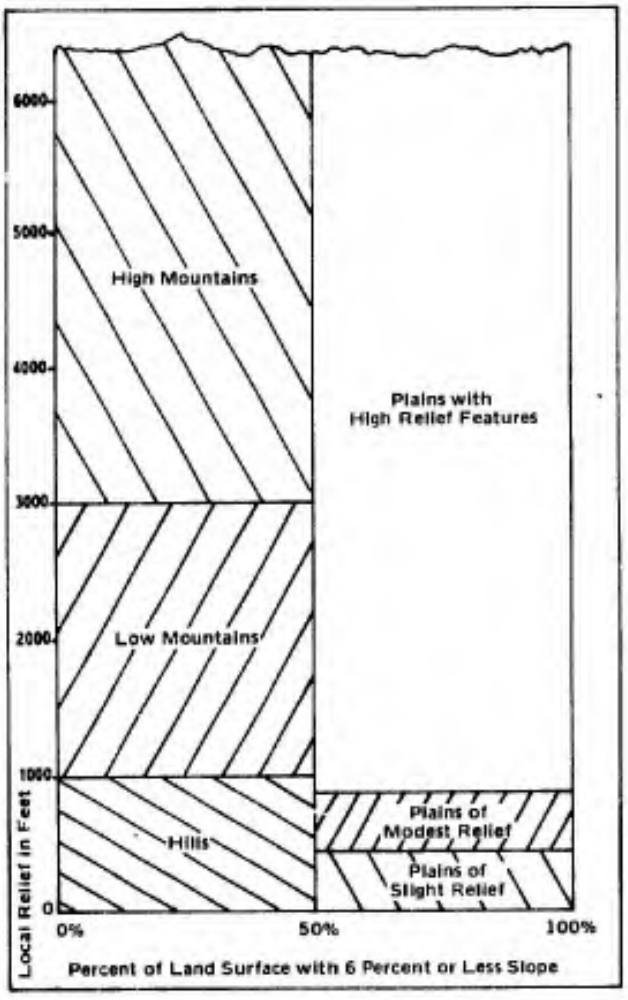


Figure 21. Terrain Types of the World

For purposes of description the schematic graph in Figure 21 will permit a quick identification of basic terrain types from topographic maps. The more common types of landform constituent materials can usually be identified fairly easily in the field.

This initial breakdown of landform types is based upon only two descriptive attributes of topography—local relief and slope. Other important properties are: pattern, texture, constituent material, and elevation. These, along with local relief and slope, can be used to identify landforms with a considerable degree of precision.

However, the above define the landform system only at a given moment of time. Landforms are not static but are continually changing, i.e., the landform system is dynamic since landforming processes are continuously at work though the rate at which they operate varies from place to place. The factors that influence process rate include some of the attributes of landforms as well as the attributes of climate and biota. One way of illustrating this complex system is shown in Figure 22.

It is evident from the above relationships that the process attributes of landform evolution can also be considered important. Among the more important processes are weathering (disintegration and decay of rock), stream and wind erosion (removal of weathered debris by those fluids), mass wasting (direct removal of weathered material by gravity), deposition (the cessation of movement of the entrained rock debris), and soil formation (those processes of weathering that give soils their distinctive regional characteristics). It is also evident that man is an important factor in changing the rate of process operation. He does this by modifying the land surface—by changing the vegetation or destroying it, by plowing or otherwise disturbing the soil-regolith, by paving or construction or otherwise sealing the surface, by changing the chemical or physical equilibrium in the soil-regolith and so forth. These and other actions he takes reduce the natural resistances in the physical environmental

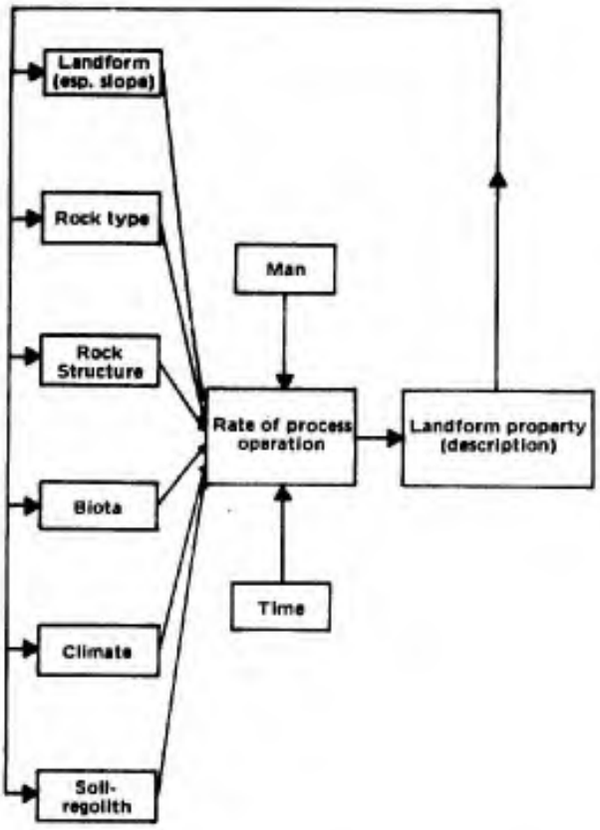


Figure 22. Landform Modification Processes

system and permit the physical processes to operate at accelerated rates—not only with respect to one attribute but to many.

Process and site attributes interact with other attributes of the natural setting in complex and subtle ways. Occasionally these relationships, when disturbed by man, produce serious repercussions to both man and the four great subsystems of the physical environment. For example, in the Piedmont of the southeastern United States, the interaction of soils, slope, climate, and the substitution of clear field cultivation of cotton and tobacco led to widespread destruction of the physical setting.

The bare, gentle-to-moderate slopes in combination with clay-rich middle layers of the local soils and the extremely heavy late summer and fall precipitation that comes with the hurricanes created circumstances of exceedingly rapid soil erosion. The intense runoff quickly formed gullies in the surface layers which, when they reached the top of the tough mid layers, commenced to meander laterally, stripping off the soil. Once gullies were eroded through the mid layers they deepened and lengthened rapidly, the water table was lowered, and the potential plant growth was thereby diminished. The process continued with damage spreading to all parts of the system, eventually returning to man with a vengeance. The vegetation was impoverished, the wildlife destroyed, and the streams were polluted with excessive sediment. This process was advanced enough that land abandonment commenced in the Piedmont began as far back as the beginning of the nineteenth century.

Thus, in the earth science technical specialty, as in all environmental relationships, interactions and interrelationships occur continuously. Process occurs at a site where attributes are impacted with a potential for local to regional environmental repercussions. A discussion of a few of these earth science attributes follows in the next section.

Review Level Attributes. The earth science attributes can be generalized into several major types of review level attributes that summarize the reactions between attributes and Army activities. Site attributes fall into four types—*slope, climate, geology,* and *soils*—whereas process attributes can logically be divided into two types—*weathering* and *potential for erosion.* Weathering is relatively a very slow activity; hence, it can frequently be omitted from consideration except in these instances where an Army activity will have an intense impact on the soil-regolith attribute of the environment or when very long range assessments must be made.

Site Review Level Attributes — Slope: A surrogate for topography (landform) since the topography consists of an assemblage of slopes of varying degree and nature. Slope is an important factor in soil erosion and plays an important role in determining drainage conditions. Slope degree and orientation also have critical influences on local patterns of microclimate.

Climate: A characterization of the temperature and precipitation of a place in terms of amount and seasonal distribution. Included also are wind intensity, prevailing winds, and kind and frequency of storms. Climate is an important factor in vegetation and soil development, in soil erosion, as well as influencing other aspects of the environment treated elsewhere.

Soils: The upper layers of the regolith or weathered rock layer. Soil has an important impact upon patterns of vegetation, agricultural

Examples of Typical Detailed Attributes.

ELEVATION

A.

The distance above sea level—the local relief of an area might only be 50 feet but its elevation might be 5000 feet. Elevation change is an important ecological factor.

B.

Army activities will have little or no effect upon elevation.

B^1.

Up to ca. 5000 feet elevation will have little effect upon Army activities. Beyond 5000 feet decreasing temperature, oxygen and atmospheric pressure impose increasingly severe stresses upon the biosphere. For example, vegetation regeneration occurs at a very slow pace at high elevations; its destruction will expose the surface to serious problems for long periods. In the human sphere, blacks frequently have sickle cell anemia which makes their systems prone to oxygen deficiency at high elevation. Many actions having minor impact at low elevations may take on serious proportions at extreme heights. For example, the occurence of permanently frozen ground (permafrost) presents all construction activities with special difficulties.

C.

Since Army activities will have virtually no effect, there are no sources of pollution upon this attribute.

D.

Since Army actions will have little or no effect upon elevations there will be virtually no direct interaction between the two.

SITE ATTRIBUTE

SLOPE

A.

The departure of the ground surface from the horizontal. The degree of departure is the most important aspect with respect to slope impacts upon Army actions. Other aspects include slope length, orientation, and surface configuration (concave, convex, straight). Comments here will be confined to interactions associated with the degree of slope.

B.

Army activities will have little or no effect upon degree of slope except on a very small scale.

B^1.

Slope inclination greater than 10 percent will place limitations on or require expensive precautionary techniques to minimize the adverse effects of construction, excavation, grading, filling, paving, or any type vegetation removal or destruction. These actions may cause accelerated slope and gully erosion that will result in soil destruction, dryer soil, lowered groundwater table, and an impoverished vegetation cover. These will combine to affect the wildlife population and increase sediment supply to streams. Increased runoff and sediment supply clogs stream channels, increases flood magnitudes, buries alluvial fans, flood-plains, and deltas with inferior or even sterile soil debris. The degree to which these events may occur depends upon the extent of activities. Small, local actions will have small, local impact, etc.

C.

Minor local changes in slope inclination can be caused by excavations or railroad or highway cuts.

D.

Since Army actions will have local and relatively minor effects upon slope inclination, the effects will be similar to B^1 above but on a small scale.

SITE ATTRIBUTE

STREAM DEPOSITION

A.

The accumulation of sediment that results from decreasing stream velocity. This may be brought about by decreasing volume of flow, decrease in gradient, increase in friction. Forms of stream deposition.

1. Alluvial fans—maximum development in semiarid and arid regions.
2. Flood plains—maximum development in humid regions, probably in the mid latitudes.
3. Deltas—maximum development where perennial streams flow into bodies of quiet water, i.e., lakes, relative tideless and current-free bays or gulfs.

B.

Increase or decrease rate of deposition.

C.

Increased rate of sedimentation may result from housing and other building construction or by destruction of vegetation cover through cutting, burning, defoliation, herbicides, grazing, cultivation. Increased sediment load will increase friction, usually by clogging channels and causing flood waters to spread laterally. Decreased rate through dam construction.

D.

Increase: Destruction of flood plains through burial by sterile sediment—same for alluvial fans and deltas. More rapid delta growth. Decrease: Increased channel erosion and damage to bridges, etc. Decrease in flood plain sedimentation; decrease in flood plain fertility, lessoning of delta growth leading to further loss. Reduction of sand supply to beaches (a real problem in southern California).

PROCESS ATTRIBUTE

MASS WASTAGE

A.

Movement of rock debris downslope through the direct action of gravity. Ways of movement range from falling to flowing, each merging with the other in such a fashion that separation is sometimes fairly arbitrary.

1. Rock fall—individual particles break away from rock and fall downslope. Any size range.
2. Rock slide—debris slide—the sliding of debris across a rock surface.
3. Land slide—movement of weathered material or overburden. Starts as a sliding motion, but on steep slopes trapped air and water may result in flowing.
4. Earth flows—flowing of debris downslope due to lubrication by air or water.
5. Slump—movement of material along a curved break; usually occurs on escarpments or steep faces in relatively unconsolidated material.
6. Regolith creep—slow, steady movement of regolith downslope.
7. Solifluction—slow flowing of weathered material that is usually contained by herbaceous root mat on top and an impervious layer below either permafrost or clay horizon.

B.

Usually regolith is held in place by internal friction, cohesion, and plant roots (introduced friction so to speak). Movement is induced by reduction in friction (wetting), loss of cohesion (wetting) of clay fraction in the regolith, addition of weight (rain, snow, or construction) destruction of vegetation, freezing and thawing, wetting and drying, diurnal heating and cooling.

C.

1. Rock fall—road and railroad cuts, construction, excavation, grading.
2. Rock slide—as in (1) above plus vegetation destruction, application of chemicals to regolith on slope, wash liquids discharged on slopes.
3. Land slide—same as (2) above.
4. Earth flows—extension of landslide as in (1) and (2) above. Onset as earth flow. Change nature of vegetation on slopes, grass to forest, for example.
5. Slump—steep slopes created by road cuts, construction, excavation, mining. On preexisting escarpments, discharge of waste fluids in regolith or overburden, blasting or operation of heavy equipment nearby. Sand depletion on beach leading to wave erosion at base of sea cliff.
6. Regolith creep—addition of waste fluids to regolith, destruction of vegetation, addition of weight on slope.
7. Solifluction—any improperly insulated construction (buildings, roads, pipelines, etc.).

D.

1. Rock fall—change in type of mass wasting. Transportation problem from rock fall.
2. Rock slide—change in type of mass wasting to more massive and rapid occurrences. Landslides lead to blocking streams, forming temporary lakes with possibilities of dangerous floods when and if dams give way. Destruction of vegetation. Increase sediment supply to steams, lowering slope angles, destruction of buildings and other structures, disruption of transportation.
3. Landslide—same as (2) above.
4. Earth flows—same as (2) and (3) above.
5. Slump—blocking transportation units, damage to buildings, sediment supply from scar, damage to vegetation (for example, some believe that areas of extensive slumping in the northern California coast is reason for some grassy areas in a normally forested region), lowers slope angle.
6. Regolith creep—damage to construction on slope; accelerated sediment supply to streams.
7. Solifluction—arctic type: destruction of construction, modify vegetation cover, change soil condition, greater sediment supply to streams.

PROCESS ATTRIBUTE

productivity, trafficability, slopewash erosion, and mass wasting.

Geology: As used here refers to the rock type and rock structure of a given location. Geology is an important factor in the development of patterns of topography, soils, vegetation, and in the distribution of mineral potential.

Process Review Level Attributes — Weathering: Includes the disintegration and decay of rock and soil formation. Slow processes, but the effects of long-term, persistent modification of vegetation cover—paving and construction, grazing, agriculture, and addition of foreign matter to soil—may produce changes in weathering deleterious to the soils of a place.

Erosion Potential: A double-edged attribute since, as the potential for soil erosion increases, so does the potential of excessive sediment loads in streams and subsequent accelerated deposition. Erosion potential reflects the interaction of degree of slope, amount of surface in significant slope, susceptibility of vegetation to destruction, soil texture, rainfall amount, and intensity and coincidence, i.e., the probability of heavy rain falling on soil shortly after it has been loosened by repeated freeze-thaw cycles.

Controversial Attributes. The attributes are listed below in decreasing order of importance:

Stream Deposition: Perhaps the problems that raise the most furor are stream channel clogging with sediment and the effects of heavy stream sediment loads upon aquatic life and stream appearance. Ugly stream channels are noticed rather quickly.

Other problems of less public urgency, but nevertheless matters of informed concerned, are increased flooding and burial of bottomland soils by inferior flood sediments.

Complete control of stream sediment may lead to other very different problems. Sediment-free stream water may use its newly acquired surplus energy to erode stream beds, undermine bridge abutments, or to change the position of stream channels destroying valuable bottomland. The natural fertilization of bottomland soils brought by normal flooding will be reduced. These results are most prominent on rivers such as the Nile, the Colorado, and the Indus.

Stream Erosion: Two attributes are involved here, the site attribute soil as well as the process attribute stream erosion. Two important aspects of stream erosion affect soils, slope wash and channel erosion, particularly on floodplains. Topsoil removal by slope and rill wash is a matter of continuing concern. So far conservation efforts are far less extensive than public belief envisions. This may become a matter of urgent concern. Land loss as a consequence of channel erosion and migration is a frequent source of strife since one man's loss is another man's gain—seemingly as the result of natural fertilization of bottomland soils brought by blamed on activities of the Army, i.e., improper watershed management, the results can be emotional indeed.

Wave Erosion: This attribute is limited to shorelines but the results can be a matter of great concern. Actions that limit the sand supply to beaches—such as damming streams from high hinterlands (i.e., the California coasts)—result in fairly prompt destruction of beaches by wave erosion. Construction of jetties or groins to keep harbors open will check the along-beach migration of sand. Where waves approach the beach at an angle most of the year (not uncommon), the sand migration is unidirectional. Hence the beach, down-migration from the groin, is "starved" for sand and is soon destroyed.

Hydrologic Regime: Floods as well as periods of abnormally low stream flow are frequently regarded as natural events. However, these natural events can be intensified and their frequency of occurrence increased by paving, construction, and destruction of vegetation cover. Property loss accompanying excessive floods can be great, whereas abnormally low stream flow may lead to stream pollution and, occasionally, outbreaks of encephalitis by creating conditions favorable to increasing the population of the mosquito species that transmits the disease.

Annual Average Temperature: Thermal pollution of the atmosphere is small at present, but it is increasing at a geometric rate. Even though the present values are extremely low (current heating of atmosphere by energy conversions is 25/1000 of one percent of the total received by the earth—a ball park estimate!), the growth rate is very large. Sooner or later it may be a problem worth noticing—and the military-industrial complex is an obvious target.

Annual Average Precipitation: Emission of gases and particles to the atmosphere may afford a greater abundance of condensation nuclei, thus increasing the local precipitation. On the scientific level, the debate about this is intense and sometimes acrimonious, at the popular level misinformation abounds but so does interest.

Selected Ramification Remarks and Mitigation Procedures. Within the earth science technical specialty most ramification remarks center around slope effects on erosion and terrain stability problems. Consequently, mitigation procedures for construction activities may involve guidelines for clearing operations and control of erosion on the site. These ideas will be developed more in the following section.

BAAPs Associated with Vegetation Removal — Ramifications: The scale of damage to the various attributes marked will depend upon the intensity of slope and rill wash which in turn are related to the extent of vegetation removal, the degree and length of slope, the physical properties of the soil, rainfall intensity, and the coincidence (if any) of freeze-thaw cycles and rain. As a rule of thumb sediment yield to streams from slopes up to 10 percent may increase by a factor ranging from three to ten or more times normal as a consequence of removing the vegetation cover. Unrestricted sediment supply will have adverse effects upon stream channel capacity to carry runoff, aquatic life, and upon areas of stream deposition, i.e., flood plains, deltas, and alluvial fans. Once vegetation is replaced, sediment yield will return to normal or nearly so. (Normal yield depends upon slope, soil condition, vegetation cover, climatic conditions, and so on.)

If the soil-regolith has a high montmorillonite clay content, clearing for construction probably should not be done on slopes with inclinations greater than 10 to 15 percent.

Wind erosion in humid climates should be slight except during late winter in cold winter climatic regions. Here the frequent freeze-thaw cycles may work the exposed soil into a mix ideal for removal by the wind, especially if strong winds coincide with hard frosts.

Mitigating Practices:

1. Clear only as much area as absolutely necessary for activity.
2. Plan to clear during the dry season (if any).
3. Avoid leaving cleared areas vacant, i.e., dovetail clearing and construction.
4. If slopes in excess of 10 percent are present, leave them covered with vegetation.
5. Construct sediment check dams on streams leading away from clearing site.
6. Use sod rather than seed for new lawns.
7. If areas must be left bare, seed with rye grass.

BAAPs Associated with Demolition—Ramifications: Demolition may make unusual particles available to streams as sediment. Impact on streams and features of stream deposition should be local and slight from the standpoint of amount of sediment added. However, the nature of the effect of the particulate matter upon aquatic life probably should be checked.

Mitigating Practices: There should be little need for protective measures unless the particulate matter resulting from demolition proves to have an adverse effect on aquatic life. If so, sediment traps should be used on streams leading away from area and demolition (if possible) for dry periods should be scheduled.

BAAPs Associated with Removal and Disposal — Ramifications: Burning as a means of disposing of dead vegetation and lumber should have little effect upon the attributes of landforms. Burning for clearing in areas where slopes exceed 6 percent will produce many of the effects cited for clearing, grubbing, and stumping BAAPs. Burning also may have an adverse effect upon the humus content of soils and upon soil structure. This will influence the nature of subsequent vegetation and the susceptibility of the soil to slope wash erosion.

Mitigating Practices for Clearing; There should be no burning except on gentle slopes and where soil quality is not a consideration.

BAAPs Associated with Excavation — Ramifications: Excavation for construction may increase sediment yield from the area of 100 to 10,000 or more times normal. This will result in ugly, clogged stream channels, burial of flood plains, increased flood magnitude, and destruction of aquatic life. Once construction is complete and the area's new vegetation cover is established, the sediment yield should return to normal. Mass wasting (gravity movement)—slides and slumps—are frequently triggered by excavations. Wind erosion may become a problem in winter.

Mitigating Practices:

1. Complete construction as quickly as possible.
2. Excavate and build during dry season (if any) if possible.
3. Avoid slopes in excess of 15 percent where regolith is rich in montmorillonite clays.
4. Disperse excavations.
5. Sediment check dams.
6. Plant belts of rye grass around excavation site.
7. Keep gradients of spoil heaps below 10 percent or plant to rye grass (if possible).

Land Use.

Introductory Commentary. All social and economic activities are located in time and space. The spatial or locational aspects of these activities involve land in some way. Thus land is a resource; i.e., it is useful in the production of goods and services needed to satisfy human wants and desires.

Land may be used directly as in agriculture or forestry where production depends in part on the inherent capability of the soil and where land serves to locate the activity in space. Or land may provide mainly the locational base upon which all sorts of commercial structures, transportation, and communication facilities or residential housing are built, and on which all sorts of social and economic activities take place.

Army activities affect, mainly, the availability or suitability of land for certain uses and thus land use patterns. The activities may have negative or positive repercussions of varying magnitude on the economy of the local community or the region, or on the social or cultural patterns of the military or civilian comunities, or on the biophysical characteristics of the land itself, depending on the nature and extent of the activity. For instance, increases in personnel due to transfers to the base may cause shortages of presently available rental housing with rent increases. However, increased housing demand may stimulate residential and related construction requiring more land with beneficial economic and social effects, Similarly, increased local procurement of meat, dairy products, or fresh fruit and vegetables for commissaries and dining halls may encourage more intensive grazing and truck farming with possible resulting beneficial or detrimental changes in land use patterns. Or base personnel may tax the capacity of local indoor or outdoor recreation facilities beyond design limits, sometimes to the detriment or destruction of these resources or force the conversion of wild lands to more developed recreational areas.

Some Army activities can affect the present or potential suitability of land for certain uses rather than its availability. For example, the establishment of an armored unit training area near the perimeter of an installation would seriously limit the adjacent land for use as a school site or for housing. On the other hand, where the adjacent land is being used for heavy industry, sanitary landfill, or warehouse, its potential would be much less affected. Thus the

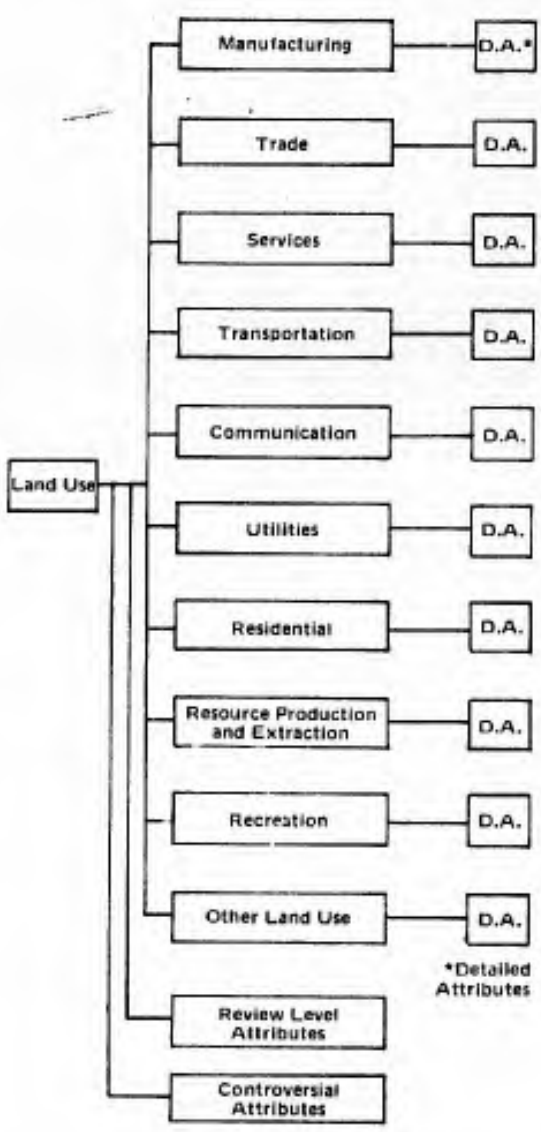
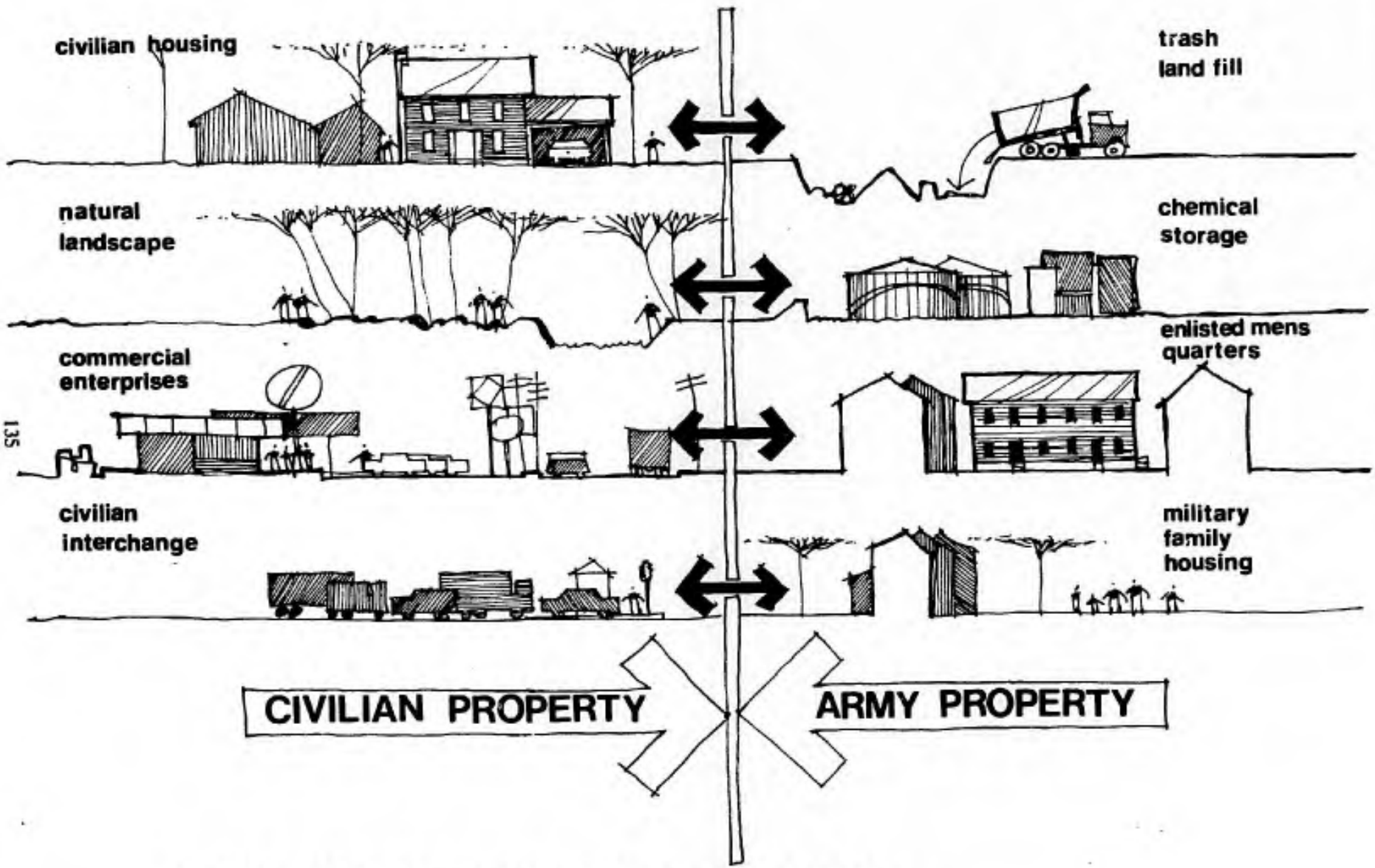


Figure 23. Attribute Hierarchy for Land Use



LAND USE PATTERNS AND THE ARMY

Examples of Typical Detailed Attributes.

TRADE – FOOD AND RELATED PRODUCTS

A.

Trade in food and related products includes sale of:

1. Groceries - fresh, processed, and manufactured foods and beverages
2. Raw agricultural crops and livestock
3. Prepared foods and beverages in eating and drinking places

B.

Trade or commerce is related to land use in that trading establishments such as grocery stores, restaurants, and taverns occupy land area. To a certain extent trade may take place on military bases, but usually most trade is located in or near the local community, city, or metropolitan area. Land (and the buildings on the land) associated with trade in food and related products can be changed in amount and location, by changes in military programs, particularly by BAAPs which affect demand for trade in these products.

C.

Acquisition or disposal of military land holdings could affect the availability of land with utility for trade in food and related products, but this impact would probably be minor unless the program affected rurally located land already in use, or potentially useful for trade purposes.

BAAPs which affect the demand for food and related products, such as activities requiring increases or decreases in military personnel, can affect the magnitude of trade in the local area, or over a wider area, and hence the demand for space (land and buildings) needed for the conduct of trade in food and related products. Changes in construction activities and related services may also become involved.

D.

Direct effects on: the development, operation, or output of establishments selling food and related products.

Indirect effects on: local government sales tax revenues and general level of economic activity in local communities or over a wider area, depending on the magnitude of demand changes; land or property values.

EXAMPLE OF A LAND USE ATTRIBUTE RELATED TO TRADE

TRANSPORTATION — AIRPORTS AND FLYING FIELDS

A.

Land use for airport and flying field transportation facilities, including:

1. Landing/takeoff runways and fields
2. Terminals, passengers, and freight
3. Storage and maintenance facilities

B.

Land available for airports and airfields, both on and off a military base, can be affected by military programs which involve changes in land use requirements. Presently established airports, airfields, and their related facilities, can be eliminated if land they occupy is removed, or if relocation is involved. Land presently used for other purposes may be severely affected if they must be acquired for new facilities, especially if it is located off the base. The operation of both military and civilian airports and airfields can be impacted by BAAPs affecting the safety of persons using these facilities.

C.

Acquisition or disposal of military land, or land use changes, which can affect availability and location of land useful for airports, airfields, and related facilities.

BAAPs affecting safety in the use of airports and flying fields.

D.

Direct effects on: location and operation of airports and airfields.

Indirect effects on: convenience and safety of the public or military in use of air transportation; land values.

EXAMPLE OF A LAND USE ATTRIBUTE RELATED TO TRANSPORTATION

RECREATION — Outdoor, Water-based

A.

Surface waters such as:

1. Lakes and reservoirs
2. Ponds
3. Rivers and streams
4. Oceans
5. Swamps and estuaries
6. Beaches and shores

These waters can provide many kinds of water-based recreational opportunities, including:

1. Swimming
2. Water skiing
3. Boating, sailing, and canoeing
4. Fishing
5. Skin and scuba diving
6. Hunting

B.

The amount, availability, and suitability of water and related lands for pursuing water-based outdoor recreational opportunities, including water quality and the recreational quality of lands surrounding surface waters, can be altered by military land acquisition or disposal and by changes in demand for these activities related to changing size of military programs. Certain BAAPs may detract from the quality of the recreation experience or make it unsafe.

C.

1. BAAPs which create water pollution and pollution of lands and air surrounding surface waters.
2. Changes in the size and depth of the water area and zoning of waters for certain uses related to certain BAAPs.
3. Demand for water-based recreational activities.

D.

Direct effects on: use of surface waters for recreational activities, including total use and the distribution of total use over time, space, and activity; user groups, e.g., boating and fishing clubs and socio-economic classes of people; and the quality for the recreational experience; costs of providing the recreation experience.

Indirect effects on: welfare of military personnel and residents of local communities.

EXAMPLE OF A LAND USE ATTRIBUTE RELATED TO RECREATION

ramifications of Army activities may reach far beyond the perimeter of the base in diverse ways.

Using the Standard Land Use Manual of the Department of Commerce and the Standard Industrial Classification Code Manual, land resources were separated into ten broad categories. These were suitability of land for use in manufacturing, trade, services, transportation, communications, utilities, residential housing, resource production and extraction, recreation, and other uses, including watershed management and wildlife habitat. Consideration was also given to land whose use is best kept in the completely wild state for aesthetic, historical, or physiographic reasons. The individual attributes were examined and potential impacts upon them noted. *Some selected detailed attributes of land use are discussed in the next section.The hierarchy of land use attributes is shown in Figure 23.

Review Level Attributes. Review level land use attributes are composites of selected specific land use attributes. The review level attributes are designed so there are (1) major similarities within each attribute and (2) major differences among elements. For example, the agriculture, forestry, fisheries, and mining attribute contains land uses which are all related to resource production and extraction, but which may be quite different than land uses for the preservation of natural and cultural resources attribute.

The suitability of land for manufacturing, trade and services, housing; indoor recreation, transportation, communication, and utilities includes land use activities which are primarily dependent on man-made structures, such as buildings and roads, and which involve various kinds of economic activities, such as the production of goods and services used in our society.

The availability and suitability of land as well as the demand for land for this attribute can be altered. For example, the availability of land for manufacturing can be decreased if the military acquires private or public lands which currently support manufacturing activities or which have potential for such activities. The suitability of land for housing can be impaired if the military pursues activities which directly affect the land, such as activities which alter drainage patterns, or which affect the health and safety of people, such as the creation of loud noises or unpleasant odors. The demand for land for transportation facilities (e.g., roads) can be increased if the number of military personnel or the size of the military installation is significantly increased.

The *agriculture, forestry, fisheries, and mining* attribute includes land use activities involved in resource production and extraction which are directly dependent upon specific characteristics of land resources themselves, such as soil fertility and drainage patterns of agricultural land and the water quality of commercial fishing grounds.

The availability of land for agriculture can be decreased if the military acquires private or public lands which are currently used for agriculture or which have potential for agricultural production. The suitability of surface waters for commercial fisheries can be decreased if military activities result in water pollution. The demand for land for agriculture can be changed if the military procures large amounts of agricultural commodities produced by local farmers.

Outdoor recreation includes land and water used for swimming, fishing, camping, nature study, hunting, and winter sports.

The availability and suitability of land as well as the demand for land for outdoor recreation can be altered in several ways. For example, the availability of land for recreation can be decreased if the military acquires private or public lands which are currently used for recreation or which have potential for this element. The suitability of land or water for recreation can be impaired by military activities which pollute the land, water, or air, or which otherwise alter or destroy the natural ecosystem. The demand for land or water for outdoor recreation can be increased if the populations of the military and local communities increase.

Preservation of natural and cultural resources includes land used for the preservation and/or protection of:

1. Archeological, biological, geological, historical, and water resources;

*It is recognized that impacts were discussed only in terms of a BAAPs effect on the suitability of land for a specified use. No mention was made of the compatibility of adjacent land uses in either an Army creation or solely "on base" context. This represents a serious shortcoming of the section which will be rectified in the future.

2. Unique natural areas (e.g., virgin redwood forests) and man-made facilities (e.g., Mount Rushmore sculpture);
3. Watersheds; and
4. Wildlife.

Natural and cultural resources can be damaged or totally destroyed, or their usefulness can be impaired in several ways. For example, the value of an archeological site for scientific study can be damaged by operation of military vehicles over the site, or totally destroyed by the impact of explosives. The usefulness of a watershed can be impaired by land-clearing activities.

Scenic beauty is a composite of factors of the landscape which imparts a particular pleasant or unpleasant image to people. Included in the composite may be: confinement of view, unique natural or man-made features, scenic views or vistas, presence of people and automobiles, construction scars, odors, visual aspects of water quality, natural vegetation cover, and air quality.

Scenic beauty can be increased or decreased by military activities which affect any of the composite factors. For example, landscaping around military facilities can increase scenic beauty; water turbidity resulting from military activities can detract from scenic beauty.

Controversial Attributes. People have become more aware of all aspects of their environment, socio-economic as well as biophysical, and thus are placing increasing importance on environmental quality now and for the future.

Controversy regarding environmental quality arises when people become dissatisfied with some aspect of their surrounding and express this dissatisfaction vocally; through pressure on elected officials; by participation in the activities of environmentally oriented pressure groups; by legal action; or by other means.

Controversy regarding land use attributes arises when people believe that Army activities may, in some way, impair, totally destroy, damage, or limit the availability of land resources for certain use while many other attributes might be listed, in this report the major controversial land use attributes are the following:

1. Outdoor recreation;
2. Preservation of natural and cultural resources; and
3. Scenic beauty.

Outdoor Recreation includes land and water used for outdoor recreational activities, such as swimming, fishing, camping, nature study, hunting, and winter sports.

The availability and suitability of land as well as the demand for land for outdoor recreation can be altered by Army activities. For example, the availability of land for recreation can be decreased if the military acquires private or public lands which are currently used for recreation or which have potential for this element. The suitability of land or water for recreation can be impaired by military activities which pollute the land, water, or air, or which otherwise alter or destroy the natural ecosystem. The demand for land or water for outdoor recreation can be increased if the populations of the military and local communities increase.

People in our society are demanding more and higher quality outdoor recreational opportunities because they are more mobile, have more leisure time, have higher incomes, are more aware of the diversity of recreational activities, and feel that recreation provides for a happier and more productive life.

The controversy arises because the demand for outdoor recreational opportunities frequently exceeds the supply in terms of quality and quantity. People become dissatisfied when military activities decrease or limit existing or potential resources for outdoor recreation or impair the quality of those resources.

A second major controversial element is the *preservation of natural and cultural resources.* This includes land used for the preservation and/or protection of:

1. Archeological, biological, geological, historical, and water resources;
2. Unique natural areas (e.g., virgin redwood forests) and man-made facilities (e.g., Mount Rushmore sculpture);
3. Watersheds; and
4. Wildlife.

Natural and cultural resources can be damaged or totally destroyed, or their usefulness can be impaired in several ways. For example, the value of an archeological site for scientific study can be damaged by operation of military vehicles over the site, or totally destroyed by the impact of explosives.

The usefulness of a watershed can be impaired by land-clearing activities.

People in our society have become more aware of their surroundings, and thus are placing increased importance on the preservation of both natural and cultural resources. There is a nostalgic feeling for resources which once existed, and people now wish to preserve the remaining natural or cultural resources for future use and enjoyment. In addition, preservation of natural and cultural resources can affect scenic beauty which in itself is a controversial element. Furthermore, people recognize that preservation of our natural ecosystems can affect other land uses and even man's existence.

Scenic beauty is a composite of factors of the landscape which imparts a particular pleasant or unpleasant image to people. Included in the composite may be: confinement of view, unique natural, or man-made features, scenic views or vistas, presence of people and automobiles, construction scars, odors, visual aspects of water quality, natural vegetation cover, and air quality.

Scenic beauty can be increased or decreased by military activities which affect any of the composite factors. For example, landscaping around military facilities can increase scenic beauty, water turbidity resulting from military activities can detract from scenic beauty. When scenic beauty is impaired, e.g., by military activities, people feel that this detracts from the quality of life. Conversely, if scenic beauty is increased people feel their welfare is improved.

Selected Ramification Remarks and Mitigation Procedures. The range of potential ramifications within the land use technical specialty covers nearly all sectors of environmental impact research. Among others, air quality, water quality, and land management practices all come into consideration as potentially modified disciplines due to the intersection of Army activities and the environment.

Clearing — Ramifications: If large areas are cleared, availability of forage for wildlife or livestock may be decreased.

Mitigation Procedure: If avoidable, steep slopes should not be cleared, particularly on erodible soils in areas of heavy rainfall; the land should be revegetated as soon as possible.

Demolition — Ramifications: If demolition noise and dust are intense or prolonged, they may affect the normal day-to-day activities of people; demolition may alter the characteristics of the land for any particular use; wildlife may be affected if noise is near and prolonged.

Mitigation Procedure: Keep use of blasting and jackhammers to a minimum or use some other method; or demolish at times when impacts are minimized.

Quarrying and Dumping — Ramifications: Residence, recreation, manufacturing, wildlife, and livestock could be adversely affected if prolonged blasting is used.

Indiscriminate dumping of rock and soil can affect landscape aesthetics or modify drainage patterns; creation of quarry pits can affect site suitability for recreation, especially water-based recreation.

Mitigation Procedures. If possible use sanitary landfill facility for spoils; level if necessary.

Noise.

Introductory Commentary. Noise is one of the most pervasive environmental problems. The Report to the President and Congress on Noise indicates that between 80-100 million people are bothered by environmental noise on a daily basis and approximately 40 million are adversely affected in terms of health.[60] Relative to the occupational environment, hearing loss primarily due to noise is considered the leading occupational disability.[61]

Since noise is a by-product of human activity, the area of exposure increases as a function of population growth, mobility, and power generation.

U.S. Army activities contribute significantly to the environmental noise problem due to both surface and airborne activities. Sound level data of military noise sources indicates that the military environment is capable of being a nuisance and a hazard to health.[62, 63] Some examples of Army-generated noise sources are listed in Table 5.

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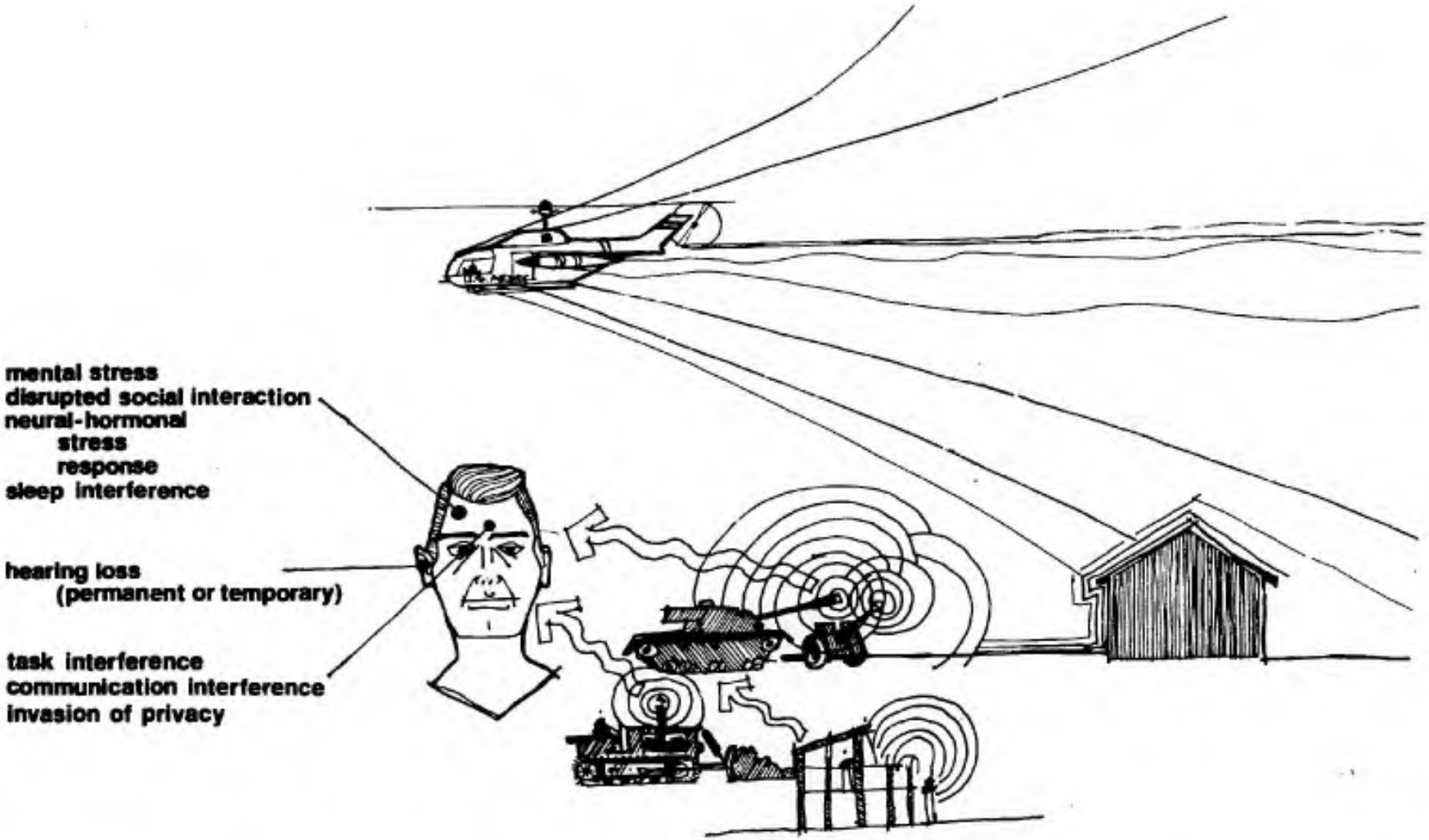
[60] U.S. Environmental Protection Agency, *Report to the President and Congress on Noise*, December 31, 1971 (USGPO, 1972).

[61] Clifford R. Bragdon, *Noise Pollution: The Unquiet Crisis* (University of Pennsylvania Press, 1971).

[62] *Sound Level Data of Military Noise Sources*, Technical Guide (U.S. Army Environmental Hygiene Agency, 1972).

[63] Army Research Office, Office of the Chief of Research and Development, "A Review of Adverse Biomedical Effects of Sound in the Military Environment" (Department of the Army, 1971).



TYPICAL NOISE IMPACTS ASSOCIATED WITH ARMY ACTIVITIES

Table 5

Army-Generated Noise Sources

WEAPONS

1. Individual small arms
2. Crew-served small arms
3. Artillery
4. Missile systems
5. Armament subsystems

AIR TRANSPORTATION

1. Rotary wing
2. Fixed wing
3. Short takeoff landing
4. General

SURFACE TRANSPORTATION

1. Vehicles/combat
2. Vehicles/noncombat
3. Rail

MARINE TRANSPORTATION

1. Combat
2. Noncombat

MACHINERY/FABRICATION

1. Chemical
2. Metalworking
3. Woodworking
4. Paper, printing, publishing
5. Textile, apparel
6. Pneumatic
7. Data
8. Food
9. Leather

MACHINERY/GENERATION

1. Communication
2. Compressors
3. Generators
4. Heating/ventilation
5. Wind tunnel

MAINTENANCE

1. Floor waxers
2. Lawn mowers

OFFICE MACHINES

1. Typewriters
2. Facsimile
3. Mechanical calculators

The military constitutes the largest population risking hearing loss. Over 90,000 veterans have a service-connected hearing disability due to noise.[64] Over $35 million a year are awarded in noise-related compensation claims.[65] Since World War II, this has amounted to nearly $1 billion.[66, 67] A variety of Army materiel is potentially hazardous to hearing depending upon the intensity and duration of exposure. This includes all weapon systems, most combat and support vehicles, and construction equipment.

Speech communication interference problems are common in the military environment as well. High ambient or background noise levels associated with Army data processing facilities have been responsible for misunderstanding messages, resulting in costly computer errors. Radio communication interference due to improperly designed microphones for military headsets has compromised pilot safety.[68]

Community annoyance is increasingly precipitated by military activities, particularly in populated areas, has become an increasing source of community annoyance. Many military installations are either involved in litigation proceedings or are being investigated as a result of congressional inquiries by other federal agencies (e.g., U.S. Environmental Protection Agency) due to nose-related activities.[69]

The *health effects* of noise are substantial. It has been reported that 50 to 70 percent of the United States population is annoyed by noise on a daily basis;[70] resulting social and psychological stresses are of major concern to the scientists and planners. The implicated health and related effects due to noise include:

[64] Clifford R. Bragdon, *Noise Pollution: The Unquiet Crisis* (University of Pennsylvania Press, 1971).
[65] Brian E. Walden, *The Extent of Hearing Loss in the Army: A Survey Report*, Walter Reed Medical Center (Department of the Army, 1971).
[66] Clifford R. Bragdon, *Noise Pollution: The Unquiet Crisis* (University of Pennsylvania Press, 1971).
[67] Brian E. Walden, *The Extent of Hearing Loss in the Army: A Survey Report*, Walter Reed Medical Center (Department of the Army, 1971).
[68] Clifford R. Bragdon, *Noise Pollution: The Unquiet Crisis* (University of Pennsylvania Press, 1971).
[69] U. S. Environmental Protection Agency, Office of Noise Abatement and Control (personal communication between R. K. Jain and C. R. Bragdon) (March 1973).
[70] U.S. Environmental Protection Agency, *Report to the President and Congress on Noise*, December 31, 1971 (USGPO, 1972).

The implicated health and related effects due to noise include:

1. Permanent or temporary hearing loss;
2. Sleep interference;
3. Increased human annoyance;
4. Communication interference resulting in reduced worker efficiency;
5. Impairment of mental and creative type of work performance; and
6. Possible increase in usage of drugs like sleeping pills because this is a method of adaptation to noise stress.[71]

Damage to physical objects is another important consideration. Many natural and man-made features in the environment have become increasingly vulnerable to an ever expanding technology of which noise is a by-product. Damages associated with noise exposure include:

1. Structural impairment;
2. Property devaluation; and
3. Land use incompatability.

Currently the dollar value for damages being sought by plaintiffs for transportation-noise amounts to $4.0 billion.[72]

The noise attributes have been divided into *sound quality* attributes which result in *human activity impacts*. Figure 24 shows the hierarchy of the attributes and a description follows. For this technical area of specialty, detailed and review level attributes are the same. Additional research will be done to further enumerate and identify the different levels of attributes.

Table 6

Human Activity Impact

PHYSIOLOGICAL EFFECTS

1. Vasoconstriction
2. Gastrointestinal modification
3. Endocrine stimulation
4. Respiratory modification
5. Galvanic skin resistance alteration

HEARING IMPAIRMENT

1. Permanent/temporary hearing loss
2. Recruitment
3. Tinnitus

COMMUNICATION INTERFERENCE

1. Aural-face-to-face; telephone
2. Visual - distortion; color blindness

TASK INTERFERENCE

1. Reduced production
2. Increased error rate
3. Extended output

SLEEP INTERFERENCE

1. Electroencephalographic modification (EEG)
2. Sleep stage alteration
3. Awakening
4. Medication

PERSONAL BEHAVIOR

1. Annoyance
2. Anxiety - nervousness
3. Fear
4. Misfeasance

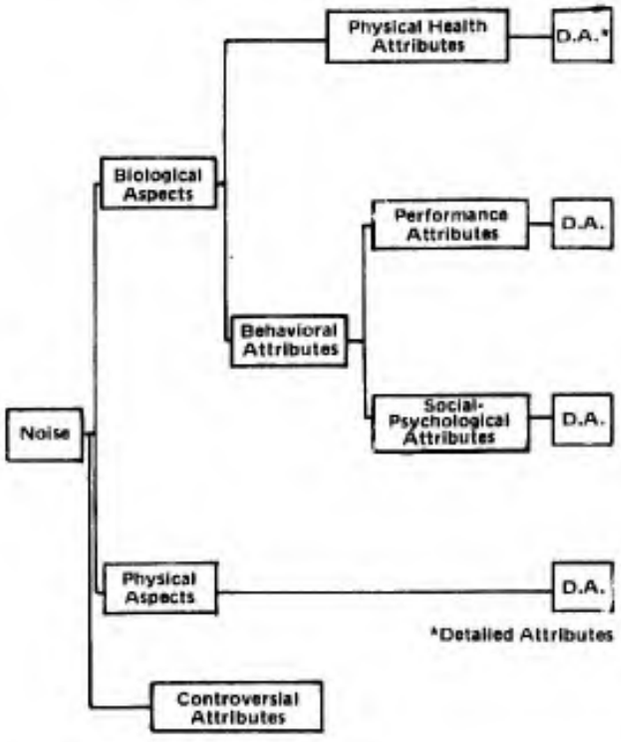


Figure 24. Noise Attribute Hierarchy

[71] Clifford R. Bragdon, "Community Noise: A Status Report," paper presented at the 84th meeting of the Acoustical Society of America, November 1972, Miami, Florida.

[72] Clifford R. Bragdon, "Noise Control in Urban Planning," *Journal of Urban Planning and Development Division*, Vol 99, No. 1 (American Society of Civil Engineers, 1973).

Examples of Typical Detailed Attributes.

PHYSIOLOGICAL MAINTENANCE

A. *Definition.* The physiological maintenance of certain human body systems (i.e., cardiovascular, musculoskeletal, endocrine, etc.) are essential for life support. Acoustic stimulation of auditory nerve fibers may constitute an arousal or stress response potentially deleterious to physiological maintenance since auditory perception in higher cortical centers generates efferent nerve impulses capable of stimulating certain human body systems.

B. *Effect.* There are a variety of physiological responses associated with noise exposure. These responses include a rise in blood pressure, increased heart and respiratory rates, muscular contraction, galvanic skin response, digestive modification, and peripheral vasoconstriction.

Although these responses do occur there are questions as to whether these changes are temporary or prolonged. Generally, adaptation occurs after the onset of noise exposure. However, the circulatory system does not appear to have an adapative mechanism at intensities above 70 dB. Peripheral vasoconstriction occurs which narrows the terminal arterioles, thereby either decreasing circulation to the extremities or increasing the arterial blood pressure. It is not known at which level there may be an irreversible or pathological response. This would be dependent upon the population at risk, intensity and duration of exposure.

C. *Source.* Both occupational as well as community-generated noise sources would be potential impactors. Most Army-generated noise sources are sufficient to affect the physiological maintenance of personnel.

D. *Criteria.* Based on existing research at this point in time it appears that 70 dB is the approximate threshold. Above that level regardless of duration peripheral vasoconstriction appears among subjects tested. However, there is no known pathological or irreversible level where permanent circulatory damage may occur. Certain populations are more susceptible, particularly the elderly, or those having circulatory problems.

EXAMPLE OF NOISE ATTRIBUTE RELATED TO PHYSIOLOGICAL EFFECTS OF NOISE

COMMUNICATION

A. *Definition.* Aural communication, or the ability to give and receive information, signals, or messages, is an essential human activity. The temporary interference of noise with the proper functioning of the auditory system during phases of human activity can be annoying, and occasionally hazardous to personal well-being.

B. *Effect.* Interference with communication occurs when the background or ambient noise levels of the environment are of sufficient intensity so as to mask speech. Noise that interferes with communication can be dangerous, particularly when a message intended to alert a person to danger is masked. More commonly noise is annoying because it disrupts the communication process. During extremely high levels of intensity exceeding 120 dB, visual impairment has been reported.

C. *Source.* Both occupational as well as community-generated noise sources would be potential impactors. Most Army-generated noise sources are sufficient to interfere with communication.

D. *Criteria.* Speech interference levels (SIL) have been established based upon the average decibel (dBC) reading for three octave bands (500, 1000, 2000 Hz), or the overall A-weighted network (dBA). The SIL represent maximum permissible levels of background noise for possible communication. In face-to-face communication, these levels are dependent upon the distance from speaker to listener and the speech conversation volume. For example, at a speaker-listener distance of 3 feet using normal conversational volume 70 dBA is the recommended maximum allowable ambient level. Above this, speech interference will occur along with increasing annoyance among the listener(s).

EXAMPLE OF NOISE ATTRIBUTE RELATED TO COMMUNICATION INTERFERENCE

TASK PERFORMANCE

A. *Definition.* Task performance, or the ability to accomplish an assignment or requirement, is influenced by noise exposure. Tasks may include either those assigned or self-imposed. The type and complexity of the task may vary as well, from a simple mechanical or manual routine-type activity to the very imaginative or creative.

B. *Effect.* The influence of noise is somewhat task-dependent. Lower order tasks such as mechanical assembly that require minor mental concentration are least influenced by noise. Tasks of this nature are altered in three essential ways, however; output, although remaining fairly constant, worker errors will increase, judgement of time intervals will become distorted, and a greater effort is necessary to remain alert. The threshold for task performance at this level is considered 90 dB.

Higher order tasks requiring greater mental faculties (problem solving, creative thinking), although dependent upon the individual, is generally disrupted by a lower noise intensity.

C. *Source.* Both occupational as well as community-generated noise sources would be potential impactors. Many Army-generated noise sources are sufficient to affect low as well as high order tasks.

D. *Criteria.* For low-order, manual, or mentally repetitious tasks, 90 dB is considered a threshold for effective performance. However, currently there are no criteria for high-order mental tasks. It is generally agreed such activities are more vulnerable to noise exposure, but there is no consensus as to criteria. General requirements for acoustical background levels for rooms appear to be somewhat applicable. A series of noise-criterion curves (NC) have been developed as design goals for background noise levels within various offices (i.e., clerical, conference, executive).

EXAMPLE OF NOISE ATTRIBUTE RELATED TO TASK PERFORMANCE

SOCIAL BEHAVIOR

A. *Definition.* Social behavior refers to the individual's ability to mentally function or act in a normal manner on an interpersonal basis. Interpersonal behavior is essential for individual as well as group maintenance. Noise, like other stimuli, may have an adverse effect upon social behavior and subsequently interpersonal relationships.

B. *Effect.* Under certain conditions within communities interpersonal relationships are altered when noise is of sufficient intensity. Areas of socialization may become restricted due to noise exposure. Outdoor areas are the first to be affected, which may limit socialization to residential interiors. Patterns of entertaining become confined and restricted.

Misunderstandings between persons, attributable to noise but not recognized as such, jeopardize friendships also. People in high noise areas may become reluctant to visit or talk on the phone, especially long distance. When one or more methods of basic auditory communication (i.e., face-to-face or telephonic) are masked the channels for social interaction become limited.

C. *Sources.* Both occupational as well as community-generated noise sources could be potential impactors. Most Army-generated noise sources, particularly air-surface transportation and weapons, are capable of influencing social behavior in community environments, particularly out-of-doors.

D. *Criteria.* Criteria previously outlined under Communication should be applied to this section for both outdoor as well as indoor environments.

EXAMPLE OF NOISE ATTRIBUTE RELATED TO SOCIAL BEHAVIOR

LAND USE INTEGRITY

A. *Definition.* Land use integrity refers to the compatibility and condition of land and structure. Noise can have an adverse impact on land use including structural impairment, property devaluation, and incompatability, all of which influence the stability of a community.

B. *Effect.* Over 2000 square miles of land area in the United States are adversely affected by environmental noise. Loss in property value is attributable to a variety of noise-related activities; however, transportation noise is the leading source. Residential areas in the vicinity of airports are the primary object of litigation. Since 1955 over $16 million has been awarded to homeowners due to subsonic noise reducing the value of residential property (claims sought exceed $4 billion). The majority of noise litigation cases have concerned the constitutional taking of property (inverse condemnation) without just compensation. This has therefore primarily involved a loss in property value rather than actual structural damage.

Incompatability of land use is a growing metropolitan problem. Zoning as a land use management tool is being compromised under pressure for either commercial-industrial or residential development and expansion. There is constant pressure for residential development near major employment centers (i.e., airports, military, or industrial activities). Often less compatible residential land uses are encroaching upon commercial and industrial land uses that generate undesirable noise levels. In other situations commercial or industrial operations attempt to expand without regard for impact on adjacent residential communities.

Many times zoning variances are granted because of a desire to increase the potential tax base, convenience of a particular land parcel to employment, or the need to provide more housing. On other occasions environmental noise is not recognized in the city planning process; consequently, modes of transportation are planned or expanded with little regard for impact.

C. *Sources.* Both occupational as well as community-generated noise sources could be potential impactors. Most Army-generated noise sources, particularly air-surface transportation and weapons, are capable of influencing land use integrity, which may affect the stability of the community.

D. *Criteria.* Land use planning criteria as outlined in the U.S. Housing and Urban Development Circular 1390.2 should be used as a site planning guide. Both exterior as well as interior nonimpulsive noise levels have been established by HUD for residential site development. An attempt should be made to comply with the "acceptable" category for both aircraft as well as nonaircraft sources to avoid any potential incompatability with either planned or existing adjacent community development. The general annoyance criteria outlined in Personal Behavior should also be used as a general guide for comprehensively assessing and evaluating land use development plans.

EXAMPLE OF NOISE ATTRIBUTE RELATED TO LAND USE

The detailed environmental attributes of sound quality have been divided into eight categories which represent the range of noise impact from potential physical health parameters (physiological maintenance and hearing threshold) and human efficiency (communication, task performance, and sleep performance) to social-psychological parameters (personal behavior, social behavior). The only nonbiological parameter is land use and its implication on structural property and community maintenance.

It has already been noted how noise may affect human health and land use integrity. If a noise has an adverse impact on human physical and mental health, it is likely that the ecosystem, specifically animal life in an exposed area, is also being affected. Chronic noise annoyance and distraction may lead to (1) human error in handling and disposal of hazardous materials, thereby potentially impacting land, air and water quality, as well as (2) disrupting harmonious social interaction, by creating minor upheavals and disagreements.

On the other hand, because noise restricts the scope of land use, it also tends to depreciate the value of impacted property including undeveloped as well as developed land. Therefore the impact of noise may be far reaching, having a potential significant impact on every other environmental area (technical specialty).

Review Level Attributes. For this technical area of specialty, as previously mentioned, detailed and review level attributes are the same. Additional research will have to be done to further enumerate and identify the different levels of attributes. This will be accomplished in the next stages of this study.

Controversial Noise Attributes.

Disruption of human activity is a significant consequence of noise. The principal annoying effects of noise are a breakdown of aural communication (especially warning signals), inability to concentrate and complete tasks, and interference with sleep or other essential human activities or interactions. Some individuals are disrupted and annoyed sufficiently to complain, thereby creating a controversial situation. The Army would be involved in such a controversy if it were generating the noise (e.g., heliport, construction activities). The extent or potential for controversy is modified by such factors as: the number and identity of involved parties; degree of exposure, and quality, quantity, and legitimacy of the noise itself. Also, there is evidence that unpredictability and a feeling of lack of control of the noise impactor may be more stressful, thereby potentiating controversy.

Chronic exposure to high noise levels may cause *permanent physiological damage* to the inner ear, thereby impairing ones ability to hear. Also, accidents found to be caused by inability to detect aural warning signals, such as horns, sirens, and voice warnings, as a result of noise interruptions may lead to death, crippling, or other permanent physical impairment. Such losses of health, life, and property can lead to successful law suits or public complaints against the Army when it is found to be generating the noise in question.

Property value can be damaged directly by noise level impacts causing shattering of glass, etc., from excessive vibration, or indirectly from accidents due to human error initially caused by noise interference. Obviously such circumstances can lead to controversy and complaint.

Selected Ramification Remarks and Mitigation Procedures.

The control of noise involves essentially three components of the problem: source, path, and object. Failure to consider any one of these components will reduce the effectiveness of any proposed solutions.

Treating noise at the source is clearly the most desirable approach; however, there are technical, economical, as well as legal questions involved that may make this approach impractical. A second approach is to treat the path along which noise travels, rather than the source itself. Last, and often the least desirable solution, is to treat the noise at the site of the receiver or object.

The predominant method of industrial noise control has been receiver or object control, primarily due to economic considerations. Occupational health programs have emphasized the proper fitting and issuing of hearing protective devices (i.e., ear plugs or ear muffs) to noise-exposed personnel as an essential element of a hearing conservation program. This control method has been emphasized in the U.S. Army Hearing Conservation Program as outlined in Technical Bulletin, Army Medical Department, Number 251 (TB MED 251, revised 1971), "Noise and Conservation of Hearing."

However, engineering noise-control measures, although recommended where feasible, have not been the predominant method of control in protecting Army personnel. Army materiel noise emissions have been subject to the U.S. Army Human Engineering Laboratory Standard (HELSTD S-1-63C) since 1963 but this has not been a completely effective method of controlling the source of noise for several reasons:

1. Not all Army materiel are subject to this standard;
2. It is applicable to only new categories of Army materiel introduced after 1963;
3. Noise levels contained in the standard are not based on damage risk criteria (potential hearing loss); and
4. It does not apply to equipment once it is operational.

To overcome some of these deficiencies a U.S. Army Military Standard: Noise Limits For Army Materiel[73] is being proposed which, if implemented, would significantly change the emphasis of noise control from object-receiver to source.

An examplary noise assessment format is presented in Table 7.

The following is a more detailed discussion of mitigation methods for controlling both industrial as well as community or environmental noise, including a discussion of proposed or existing noise regulations.

The federal government has promulgated three regulations relating to *source control* of noise. These noise regulations have been issued by the Department of Labor, the General Services Administration and the Environmental Protection Agency.

1. General Services Administration. The General Services Administration issued construction noise specifications effective 1 July 1972 for earth-moving, materials handling, stationary, and impact equipment. It requires that all on-site equipment used by a contractor while under contract with the General Services Administration must meet A-weighted sound level requirements (dBA) measured 50 feet from the equipment. For example, a tractor, regardless of type must not exceed 80 dBA while operating on the site at a distance of 50 feet. Noise violations will result in a cancellation of the contract. Nearly all existing construction equipment exceed these levels; therefore, some type of engineering noise control will be necessary.

Table 7

Noise Assessment Format

ACOUSTICAL MEASUREMENT DATA

1. Continuous sampling (actual or simulated)
2. Decibels A - weighing network (dBA)
3. Consistent with professional standards
   - American National Standards Institute (ANSI)
   - Society of Automotive Engineers (SAE)

MEASUREMENT PARAMETERS

1. Existing and projected conditions
2. Most adverse environmental conditions
   - Highest volume
   - Time of day
   - Most noise-sensitive location

DATA PRESENTATION

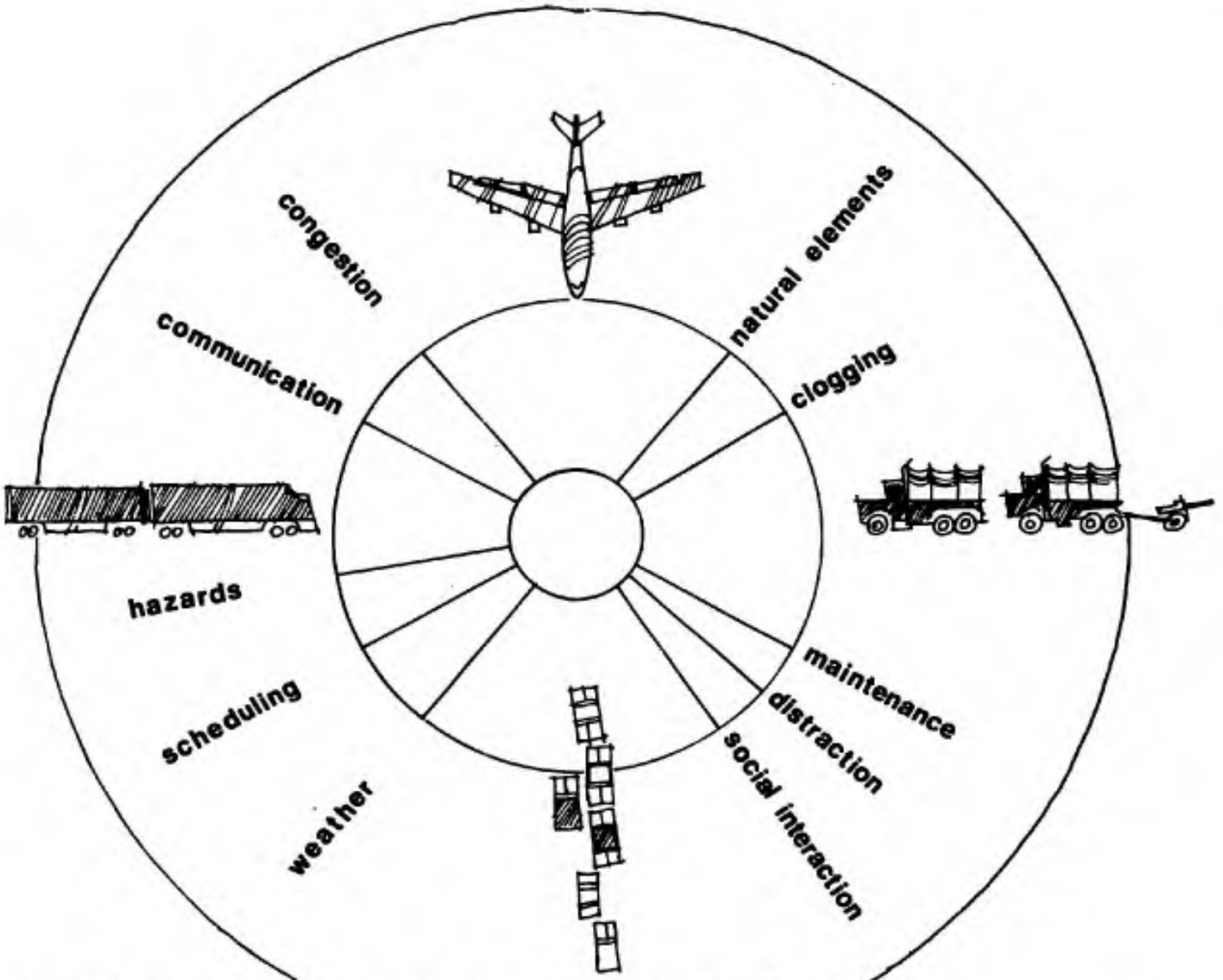
1. Noise contours (existing - proposed)
2. Land use (existing - proposed)
   - Structures
   - Population

ANALYSIS

1. Federal noise criteria
2. Alternative solutions
3. Costs and economic data

2. Environmental Protection Agency. Under the provisions of the Noise Control Act of 1972, the Environmental Protection Agency is required to

[73] "Noise Limits for Army Materiel." Personal communication between R. K. Jain and Dr. C. R. Bragdon (April, 1973).



ARMY TRANSPORTATION ACTIVITIES AND THE CIVILIAN COMMUNITY

promulgate noise emission standards for four new product categories: (a) construction equipment, (b) transportation equipment, (c) motor or engine, and (d) electrical or electronic equipment. In addition, all railroad and motor carriers engaged in interstate commerce will be subject to noise emission requirements. Furthermore, any product adversely affecting the public health or welfare will be required to be labeled with the specific sound level (see Noise Control Act of 1972). Although noise emission standards have not yet been issued, it is expected that engineering noise controls will have to be initiated.

3. Department of Labor. Noise exposure criteria have been established under the provisions of the Occupational Safety and Health Act by the Department of Labor. To meet the provisions of this act requires that a hearing conservation program be initiated for protecting noise-exposed personnel and that emphasis be placed upon engineering noise control. Hearing protective devices should be issued to the workers but only as an interim measure while engineering solutions are being planned.

There are a variety of source controls available besides the issuing of legislation or source emission requirements. These involve either administrative or engineering control.

Engineering controls include a variety of solutions that modify the noise source. These solutions may include damping, absorption, dissipation, and deflection methods. Common techniques involve constructing sound enclosures, applying mufflers, mounting noise source on isolators, and/or using materials with damping properties. Predesigning the mechanical operation of the noise source may be necessary also.

Performance specifications for noise represent a way to insure the item procured is controlled. The cost of noise abatement varies with the source, degree, and type of control necessary. Generally this cost ranges from 3 to 10 percent; however, it may range as high as 30 percent.

The Army generally procures equipment without specifying any noise emission requirements. Because of cost constraints, most material is procured on a least-cost basis; therefore the majority of material has little or no noise control. In an effort to purchase diesel-powered bulldozers at minimal cost, the Army obtained a sizable number of bulldozers without any muffling device. The absence of these mufflers resulted in an operator noise level hazardous to hearing.

Administrative controls can also be applied to a noise source. These essentially involve personnel management decisions to minimize personnel exposure to noise. Included are personnel rotation or removal and issuing of hearing protection. Other decisions may involve isolation or replacement of equipment.

Transportation.

Introductory Commentary. Due to the complex nature of the transportation technical specialty two different approaches were required. First, Army transportation was considered from the standpoint of determining the impact on the *physical environment* resulting from the actual operation of military vehicles. Second, transportation was viewed from the standpoint of determining the impact on *civilian transportation systems* due to Army transportation. Distinctions between these two separate aspects of Army transportation are made below.

In considering the *impact of Army Transportation on the physical environment,* two primary functional activities are identified; they are those activities related to transportation support at a military installation and those activities that are related to the fullfillment of a training mission. Regardless of the actual type of vehicle involved, the basis of mode of operation may be classified as (1) off-road, (2) trail, or (3) road movement.

Most of the military tactical ground vehicles are given in the tables of organization and equipment for major Army commands (infantry, mechanized infantry, armored, airborne, and airmobile divisions).[74,75] During this study, many of these vehicles were classified according to their potential for environmental degradation. In order to accomplish this task, vehicles with similar characteristics and performance were grouped into categories that would probably cause similar environmental degradation.

[74] *Staff Officers' Field Manual. Organizational, Technical and Logistical-Extracts of Tables of Organization and Equipment.* FM 101-10-2 (Department of the Army, 1970).

[75] *Staff Officers' Field Manual. Organization, Technical and Logistics Data.* FM 101-10-1 (Department of the Army, 1971).

Vehicle Cone Index (VCI),* vehicle width, maximum stem diameter the vehicle can override, and number of wheels or bogies were used to establish these categories of vehicles as shown in Table 8. The first category represents vehicles that have the smallest potential for environmental degradation and the fifth category represents vehicles with the greatest potential for environmental degradation. The difference in the degree of degradation between the categories of vehicles is dependent upon the terrain condition.

Specifically, the impact on the physical environment was broken down into five separate categories, as explained below:

1. Degradation to surface composition (all modes of transportation): VCI_1 is the best descriptor for determining the degree of effect that a vehicle potentially will have on the surface composition attribute. Formulas and basic input data required to compute VCI_1 are given in Table 9 for tracked vehicles and Table 10 for wheeled vehicles.[76,77] Five categories of vehicles and related VCI_1 ranges are shown in Table 8A.

2. Degradation to surface geometry (all modes of transportation): The degradation to surface geometry attribute is normally caused by ruts formed by the running gear of the vehicle. The VCI_1, the weight of the suspension system, and the tire characteristics are all indicators of the relative potential degradation of vehicles on this attribute. At this stage of development, it is felt that VCI_1 is the best single indicator of degradation potential. A list of the categories of VCI as related to degradation of surface geometry is given in Table 8B.

3. Degradation to vegetation: The amount of degradation that a vehicle may cause to this attribute is dependent upon such vehicle characteristics as width, height of leading edge, ground clearance, and weight and such vegetation characteristics as stem diameter and spacing. The categories of vehicle degradation developed for this attribute are based on maximum stem diameter that the vehicle can override and the vehicle width; these are given in Table 8C.

4. Degradation to visibility (all modes of transportation): Although overriding vegetation, smoke emissions, etc., have effects on visibility, dust is recognized as probably the most important factor contributing to degradation of this attribute when traveling on unpaved roads and trails. For cross-country movement overridden vegetation could be the major factor in some instances. When this is the case, the vegetation degradation categories should be used. Since little information is available that can be directly related to the amount of dust a given vehicle will cause, the number of wheels or bogies on a vehicle was used to develop categories of vehicles with similar degradation effects on this attribute. The categories and their relative effects are given in Table 8D. Obviously, vehicle speed, spacing, and configuration are significant factors, and some field studies would be required to establish a data base of sufficient size to quantify dust production in different environments.

5. Degradation to hydrologic geometry features: Both amphibious and nonamphibious vehicles can cause damage to hydrologic geometry features. It is recognized that the depth of water a vehicle can ford and the shape of the vehicle determines its ability to traverse a water obstacle. However, it is felt that the amount of damage to streams or lake banks and bottoms is more closely related to the VCI of the vehicle than any other single factor. Categories of vehicles and their relative degradation of the hydrologic geometry attribute are listed in Table 8E.

Vehicle characteristics, performance data, and vehicle categories based on potential environmental

*Definitions:

Vehicle Cone Index (VCI). The minimum rating cone index (RCI) for a particular type of vehicle that will permit such a vehicle to cross a given surface medium a specified number of times. Thus VCI_{50} means the minimum RCI necessary to complete 50 passes, and VCI_1 means the minimum RCI necessary to complete one pass.

Rating Cone Index (RCI). The product of the measured CI and the RI of the same soil layer.

Cone Index (CI). An index of the shearing resistance of a medium, such as soil, obtained with a cone penetrometer. The value represents the resistance of the medium to penetration of a 30-degree cone of 0.5 sq in. base or projected area. The number, although usually considered dimensionless in trafficability studies, actually denotes pounds of force on the handle divided by the area of the cone base in square inches.

Remolding Index (RI). A ratio that expresses the proportion of original strength of a medium that will remain under a moving vehicle. The ratio is determined from cone index measurements made before and after remolding a 6 in. long sample in a 1.9 in. diameter tube.

[76] A. A. Rula, and C. J. Muttall, *An Analysis of Ground Mobility Models (ANAM03)*, Technical Report M-71-4, (U. S. Army Engineer Waterways Experiment Station (WES), CE, 1971).

[77] B. G. Schreiner and A. A. Rula, *Evaluation of the Performance of the XM759 Logistical Carrier*, Technical Report 3-808 (U.S. Army WES, 1968).

Table 8

Separation of Vehicles into Categories Based on Their Potential Degradation

A. Surface Composition Degradation

Categories of Vehicles

Category	VCI Range	Degree of Impact
1	0-20	Smallest
2	>20-30	↓
3	>30-40	
4	>40-50	
5	>50	Largest

B. Surface Geometry Degradation

Categories of Vehicles

Category	VCI Range	Degree of Impact
1	0-20	Smallest
2	>20-30	↓
3	>30-40	
4	>40-50	
5	>50	Largest

C. Vegetation Degradation Categories of Vehicles

Category	Max. Stem Dia. Vehicle Can Override* in.	Vehicle Width** ft.	Degree of Impact
1	0-4	4	Smallest
2	>4-6	>4-6	↓
3	>6-8	>6-8	
4	>8-10	>8-10	
5	>10	>10	Largest

D. Visibility Degradation (Dust)*

Categories of Vehicles

Category	No. of Wheels or Bogies	Degree of Impact
1	4	Smallest
2	6	↓
3	8	
4	10	
5	>10	Largest

E. Hydrologic Geometry Degradation

Categories of Vehicles

Category	VCI Range	Degree of Impact
1	0-20	Smallest
2	>20-30	↓
3	>30-40	
4	>40-50	
5	>50	Largest

* Select one category greater if tracked vehicle.

** When different categories are indicated by the vehicle characteristics (width, bogies, and wheels) and performance data (maximum stem diameter), select category with larger impact.

*Visibility degradation may be due to vegetation override. Where this is the predominant effect (some off-road environments), use the vegetation degradation categories.

Table 9

Mobility Index Equation for Self-Propelled Tracked Vehicles

$$\text{Mobility Index} = \left(\frac{\text{contact pressure factor} \times \text{weight factor}}{\text{track factor} \times \text{grouser factor}} + \text{bogie factor} - \text{clearance factor} \right) \times \text{engine factor} \times \text{transmission factor}$$

wherein,

$$\text{contact pressure} = \frac{\text{gross weight in lb}}{\text{area of tracks in contact with ground in sq in.}}$$

weight factor:
less than 50,000 lb = 1.0
50,000 to 69,999 lb = 1.2
70,000 to 99,999 lb = 1.4
100,000 lb or greater = 1.8

$$\text{track factor} = \frac{\text{track width in in.}}{100}$$

grouser factor:
grousers less than 1.5 in. high = 1.0
grousers more than 1.5 in. high = 1.1

$$\text{bogie factor} = \frac{\text{gross weight in lb divided by 10}}{\text{(total number of bogies on tracks in contact with ground) x (area of 1 track shoe in sq in.)}}$$

$$\text{clearance factor} = \frac{\text{clearance in in.}}{10}$$

engine factor:
10 or greater hp per ton of vehicle wt = 1.0
less than 10 hp per ton of vehicle wt = 1.05

transmission factor:
automatic = 1.0; manual = 1.05

$$VCI_1 = 7.0 + 0.2\,MI - \left(\frac{39.2}{MI + 5.6} \right)$$

$$VCI_{50} = 19.27 + 0.43\,MI - \left(\frac{125.79}{MI + 7.08} \right)$$

Table 10

Mobility Index Equation for Self-Propelled Wheeled (All-Wheel Drive) Vehicles

$$\text{Mobility Index} = \left(\frac{\text{contact pressure factor} \times \text{weight factor}}{\text{tire factor} \times \text{grouser factor}} + \text{wheel load factor} - \text{clearance factor} \right) \text{engine factor} \times \text{transmission factor}$$

where

$$\text{Contact pressure factor} = \frac{\text{gross weight, lb}}{\text{nom. tire width, in.} \times \frac{\text{outside dia. of tire, in.}}{2} \times \text{No. of tires}}$$

	Gross weight, lb / no. of axles	Weight factor equations
Weight factor:	< 2,000	Y = 0.553X
	2,000 to 13,500	Y = 0.033X + 1.050
	13,501 to 20,000	Y = 0.142X - 0.420
	< 20,000	Y = 0.278X - 3.115

Y = weight factor

X = $\frac{\text{gross weight, kips}}{\text{no. of axles}}$

Tire factor: $\frac{10 + \text{tire width, in.}}{100}$

Clearance factor: $\frac{\text{clearance, in.}}{10}$

Grouser factor: With chains = 1.05; Without chains = 1.00

Engine factor: > 10 hp/ton = 1.00; < 10 hp/ton = 1.05

Wheel load factor: $\frac{\text{gross weight, kips}}{\text{no. of axles} \times 2}$

Transmission factor: Automatic = 1.0; Manual = 1.05

$$VCI_1 = 11.48 + 0.2\,MI - \left(\frac{39.2}{MI + 3.74} \right)$$

$$VCI_{50} = 28.23 + 0.43\,MI - \left(\frac{92.67}{MI + 3.67} \right)$$

degradation are given in Tables 11, 12, and 13 for the vehicles selected for this study.

In addition to those environmental parameters explained above, other environmental disciplines that transportation activities may be expected to have an effect on include air quality, noise, and water quality. It is recommended that those sections be referred to for additional information.

Army transportation effects on the civilian transportation system is the second aspect of this technical specialty. A free-flowing transportation network is necessary for the economic and social well being of a region. Army activities which disrupt the flow of this overall system are highly visible and annoying to the civilian population. When evaluating the total impact of an Army activity, the effect on the regional transportation network must be considered.

The transportation network can be characterized initially by dividing it into four systems. These systems are:

1. Road transportation;
2. Rail transportation;
3. Air transportation; and
4. Water transportation.

It is important to note that particular activities may affect one system or a combination of systems.

Development of detailed attributes describing the impact on a transportation system, as shown in Figure 25, was achieved by considering disruption of traffic flow, damage to traffic facilities, damage to vehicles or injury to humans, and/or modification or extension of traffic facilities. Problems in the road transportation system which can serve to illustrate these detailed attributes include: traffic jams caused by slow moving Army convoys; degradation of road surfaces caused by movement of heavy Army vehicles; collisions involving damage to Army and civilian vehicles and/or personal injury, and expansion of roadway vehicle capacity or other modifications to accommodate an increase in Army personnel. When considering the impact of an Army activity on a particular system, it should be noted that an impact on one attribute may also affect another. For example, the modification of a roadway may also disrupt the traffic flow on that roadway.

The transportation technical specialty is closely interrelated with other technical specialties. Army activities which impact transportation have the potential of being passed on and magnified throughout the system. For example, the expansion

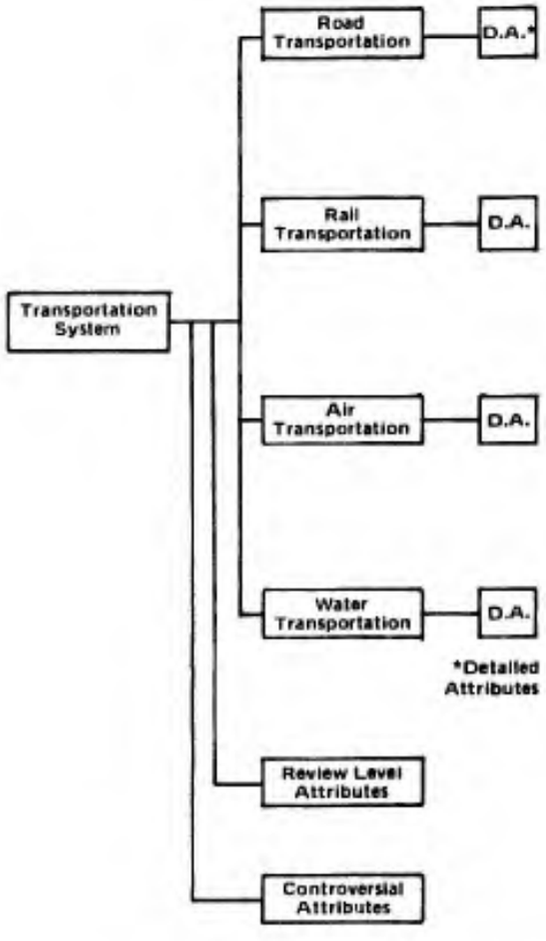


Figure 25. Attribute Hierarchy for Transportation

of an Army facility causes the overloading of the regional road system. This results in traffic delays which may lead to a higher level of noise and air pollution in the area. These higher levels affect the health of the community, the ecology of the adjacent areas, and the usage of adjacent lands. A change in the land usage pattern can then cause a change in the economics of the region which further could result in a change in the social orientation of the region's population. This process can cycle back on itself by forcing a modification of the regional road system. Conversely, because of this interrelationship, impacts within the transportation area can be amplified by the other technical specialties. For example, the climate and topography within a region can accentuate an impact on the transportation network.

This high degree of interrelation to other areas shown by transportation also creates an impact

Table 11

Characteristics, Performance Data, and Degradation of Transportation Attributes by Wheeled Military Vehicles

Vehicle Description	Line Item No.	Vehicle Characteristics: Gross Weight lb	Payload lb	Vehicle Width ft	Width in.	No. of Tires	Height of Leading Edge in.	Horsepower per ton	Vehicle Performance Data: VCI_1	Maximum Override Stem Diameter in.	Maximum Speed mph	Degradation of Transportation Attributes by Military Vehicles*: Surface Composition	Surface Geometry	Vegetation	Visibility	Hydrologic Geometry
Instrument, Repair Shop 2½-ton Truck	K90188															
M185A3 M185,M185A1,M185A2,M238		22,200	5,000	8.2	9.00-20	10	31	12.6	30	9.7	56	2**	2	4	4	2
Truck, Van Shop, 2½-ton	X62340															
M109A3 M220,M109A2,M109A1,M109		20,435	5,000	8.0	9.00-20	10	31	12.7	28	9.4	55	2	2	4	4	2
Truck, Wrecker, 5-ton	X63299															
M62 M816,M543A2,M543,M543A1		41,025	7,000	8.1	11.00-20	10	33	9.6	41	12+	52.6	4	4	5	4	4
Truck, Tractor, Wrecker, 5-Ton	X60696															
M819 M246A2, M246A1,M246		44,800	12,000	8.2	12.00-20	10	35	10.0	39	12+	53	3	3	5	4	3
Truck, Ambulance, ¼-ton	X38639															
M170 M718A1,M718		3,763	800	5.2	7.00-16	4	21	36.2	22	5.0	71	2	2	2	1	2
Truck, Ambulance, ¾-ton	X38776															
M43 M43B1		8,550	1,400	6.1	9.00-16	4	26	18.3	30	6.8	55	2	2	3	1	2
Truck, Tank, Fuel Servicing 2½-ton	X57271															
M49C M49A2C, M49A1C, M117C, M217, M49		18,955	5,000	8.0	9.00-20	10	32	13.4	27	9.2	58	2	2	4	4	2
Truck, Dump, 5-ton	X43845															
M51 M817, M51A1,M51A2		32,664	10,000	8.1	11.00-20	10	34	12.0	32	11.2	52	3	3	5	4	3
Truck, Utility, ¼-ton	X60833															
M151 M151A2,M151A1,M38,M38A1		3,073	800	5.2	7.00-16	4	21	46.0	18	4.7	65	1	1	2	1	1
Truck, Utility, ¼-ton	X61244															
M38A1C M825,M151A1C		3,490	800	5.0	7.00-16	4	21	41.1	21	4.9	55	2	2	2	1	2
Truck, Cargo, ¼-ton	X39735															
M37B1 M37		7,800	1,500	6.1	9.00-16	4	26	20.0	28	6.6	55	2	2	3	1	2
Truck, Cargo, 2½ ton	X40009															
M35 M35A2,M35A1,M211,M34, M135		17,880	5,000	8.0	9.00-20	10	33	14.2	26	9.1	58	2	2	4	4	2

Table 11 (continued)

Vehicle Description	Line Item No.	Vehicle Characteristics: Gross Weight lb	Payload lb	Vehicle Width ft	Width in.	No. of Tires	Height of Leading Edge in.	Horsepower per ton	Vehicle Performance Data: VCI_1	Maximum Override Stem Diameter in.	Maximum Speed mph	Degradation of Transportation Attributes by Military Vehicles*: Surface Composition	Surface Geometry	Vegetation	Viability	Hydrologic Geometry
Truck, Cargo, 5-ton	X40831															
M54A2 M813,M54A1,M54		30,915	10,400	8.0	11.00-20	10	33	13.6	31	11.0	53	3	3	5	4	3
Truck, Cargo, 1¼-ton	X39940															
M561		8,960	2,500	7.0	11.00-18	6	25	23.0	19	6.9	55	1	1	3	2	1
Truck, Dump, 2½-ton	X43434															
M342A2 M59,M215,M47		21,565	5,000	8.0	9.00-20	10	40	30.6	30	10.3	56	2	2	5	4	2
Truck, Tank, Fuel Servicing 2½-ton	X57408															
M49A2C M49C,M49A1C,M49		21,025	6,000	8.0	9.00-20	10	36	30.7	30	9.8	56	2	2	4	4	2
Truck, Platform, Utility ¼-ton	X55627															
M274A2 M274A5,M274A1,M274A3, M274A4, M274		1,970	800	4.1	7.50-10	4	23	6.7	13	4.1	25	1	1	2	1	1
Truck, Dump, ¾-ton† XM708, XM708E1, M708	X43228															

* Includes all transportation modes.
** See table 8 for explanation.
† No information could be gathered in the time allotted for this study.

Table 12

Characteristics, Performance Data, and Degradation of Transportation Attributes by Tracked Military Vehicles

Vehicle Description	Line Item No.	Gross Weight lb	Payload lb	Vehicle Width ft	Contact Pressure lb/sq in.	Track Width in.	No. of Bogies	Height of Leading Edge in.	Horsepower per ton	VCI_1	Maximum Override Stem Diameter in.	Maximum Speed mph	Degradation of Transportation Attributes by Military Vehicles*: Surface Composition	Surface Geometry	Vegetation	Visibility	Hydrologic Geometry
Carrier, Command and Recon, Armored	D11401																
M114 M114A1		15,600	2700	7.6	5.2	16.5	8	23	25.5	15	8.2	34	2**	2	4	3	2
Carrier, Command Post, Light Tracked	D11538																
M577A1 M577		24,260	2500	8.8	7.7	15	10	23	16.7	17	9.5	40	2	2	4	4	2
Carrier, Personnel, Full Tracked, Armored	D12086																
M113A1 M113, M59		23,380	3145	8.8	7.6	15	10	23	17.7	17	11.8	40	2	2	5	4	2
Howitzer, Heavy, Self-Propelled, 8-in.	K56981																
M55 M110		98,000		11.1	11.2	23	14	50	16.5	20	12+	35	2	2	5	5	2
Howitzer, Medium, Self-Propelled, 155 mm	K57666																
M44A1 M109, M109A1, M44		64,000		10.6	9.4	23	12	45	15.6	14	12+	35	2	2	5	5	2
Recovery Vehicle, Full Tracked, Light Armored	R50543																
M578		54,000		10.3	10.0	18	10	43	16.8	21	12+	34	3	3	5	4	3
Recovery Vehicle, Full Tracked, Medium Armored	R50680																
M88		112,000		11.2	10.5	28	12	48	17.5	20	12+	30	2	2	5	5	2
Tank, Combat, Full Tracked, 105 mm	V13100																
M60A1 M60 M48 (used as carrier for Chaparral)	J95522	105,000		11.9	11.3	28	12	45	14.2	21	12+	30	3	3	5	5	3
Armored, Recon, Airborne Assault Vehicle	A93124																
M551		33,460		9.16	6.4	17.5	10	26	17.9	15	12+	43	1	1	5	5	1

* Includes all transportation modes.
** See table 8 for explanation.

Table 13

Characteristics, Performance Data, and Degradation of Transportation Attributes by Combination Military Vehicles

Vehicle Description	Vehicle Characteristics								Vehicle Performance Data			Degradation of Transportation Attributes by Military Vehicles†				
	Line Item No.	Gross Weight lb	Payload lb	Vehicle Width ft	Tire Size	No. of Tires	Height of Leading Edge in.	Horsepower per ton	VCI	Maximum Override Stem Diameter in.	Maximum Speed mph	Surface Composition	Surface Geometry	Vegetation	Visibility	Hydrologic Geometry
*M35, 2½ Ton Truck With M105A2 Trailer	W95811	23,980	8,000	8.0	9.00-20	12	33	10.6	34	9.1	58	3††	3	4	5	3
*M35, 2½ Ton Truck With M332 Trailer	W94030	24,030	8,000	8.0	9.00-20	12	33	10.6	34	9.1	58	3	3	4	5	3
*M35, 2½ Ton Truck With M149 Trailer	W98825	24,065	10,575	8.0	9.00-20	12	33	10.6	39	9.1	58	3	3	4	5	3
*M37B1, ¾ Ton Truck With M101 Trailer	W95537	10,640	3,000	6.1	9.00-16	6	26	14.7	31	6.6	55	3	3	3	2	3
*M151, ¼ Ton Truck With M100 Trailer	W95400	4,005	1,300	5.2	7.00-16	6	21	35.5	23	4.7	65	2	2	2	2	2
*M52A2, 5 Ton Truck With M131A4C Trailer	S72983	68,398	35,250	8.1	11.00-20	18	31	6.3	50	11.2	53	4	4	5	5	4
*M52A2, 5 Ton Truck With M127A1 Trailer	S72024	56,200	24,000	8.1	11.00-20	18	31	7.5	38	11.2	53	3	3	5	5	3
*M123C, 10 Ton Truck With M15A2 Trailer	S73394	174,850	100,000	12.1	14.00-24	14	40	3.3	664	11.3	44	5	5	5	5	5
*M123C, 10 Ton Truck With M172A1 Trailer	S70517	98,600	50,000	9.6	14.00-24	18	40	5.8	85	11.3	44	5	5	5	5	5
*M275, 2½ Ton Truck With M313 Trailer	S74490	36,765	10,000	8.1	9.00-20	18	39	6.9	36	8.3	58	3	3	4	5	3
*M35, 2½ Ton Truck With M102, 105 mm Light Howitzer	K57392	22,215		8.0	9.00-20	12	33	12.0	33	9.1	50	3	3	4	5	3
*M561, 1¼ Ton Truck With M101A1, 105 mm Howitzer	K57529	13,940		7.0	11.00-18	8	25	14.9	32	6.9	55	3	3	3	3	3
*M54A2, 5 Ton Truck With M114, 155 mm Howitzer	K57803	42,640		8.0	11.00-20	12	33	9.9	37	11.0	53	3	3	5	5	3

* This is one of the vehicles recommended as prime mover for this towed vehicle.
† Includes all transportation modes.
†† See table 8 for explanation.

rating problem. Because of the great number of random variables involved in these interrelationships, the exact cost, duration, and extent of an impact is difficult to estimate. To help estimate the impact of an Army activity on a given transportation system, mathematical models of some aspect of the system (i.e., traffic flow) can be used.

Review Level Attributes. The review level attributes for transportation are:

1. Disruptions in road transportation;
2. Disruptions in rail transportation;
3. Disruptions in air transportation; and
4. Disruptions in water transportation.

Army activities resulting in disruptions to the *civilian highway transportation network* are among the most significant of any activity. The utter dependence of most populations upon automobile and truck transport of persons and goods makes disruption of the road network a highly significant ramification of many activities, especially in the area of construction. The fact that the Army is a highly visible governmental organization makes it more susceptible to criticism than a comparable civilian organization using the highways, and thus this may be an important controversial area as well. Blockage of roads by equipment and materiel causes economic losses in the transport sector of the community and delays which may or may not have measurable economic impact. They will always, however, cause public indignation and reaction.

In general, the Army is a user of *rail and water transportation* in approximately the same manner as any large commercial organization. Army activities are not expected to cause damage to either the trackage or waterway systems during use any more than any other user. Accidents involving Army equipment and personnel, however, are highly visible, and exceedingly great care should be taken to plan operations so that the chance of such accidents is minimized. If a construction activity is planned which would require very great quantities of raw materials being moved over the commercial net, such transport should be spread over as long a period as feasible. If any action within the rail yards and ports under Army control affects the civilian shipping sector, such activities should receive the closest possible scrutiny and care should be taken to avoid impaction of the sensitive activities of the commercial system.

The *civilian airways* have always been susceptible to a wide variety of degrading influences. Poor visibility was once almost entirely due to more or less natural weather phenomena, and thus merely endured. Now that it is known that industrial activities may cause haze and smog, and that clearing and construction may cause blowing dust clouds, it has become a matter of public interest to mitigate known sources of such obstructions to visibility which may interfere with on-time flight operations. If an Army installation or activity were responsible for such problems, public sentiment would be predictable, and negative. Should Army-connected flight operations be conducted in such a manner as to result in either undue noise in the civilian residential community, or congestion or possible danger to commercial flight operations, this problem would be considered very grave and would require immediate mitigation. The possibility of accidents resulting from military flight operations should not be overlooked as a potential problem, though they are not intentional. The fact that an accident might sooner or later take place must be considered, and training areas and flight paths should be evaluated so as to present the least possible hazard should an accident take place. Good emergency response to such an accident will also assist in creating favorable public opinion.

Controversial Attributes. Any large and important impact on a major transportation system caused by a BAAP could well be fairly controversial whether or not an environmental impact statement on the BAAP had been filed and was substantially correct. The reason for this is that any Army-caused impact on a major transportation system will probably have a very direct and obvious effect on a substantial number of people. Transportation attributes that would probably be particularly controversial are:

1. Modification and extension of the facilities of any transportation system (highway, rail, air, or waterway), since this might well entail the expenditure of substantial civilian funds; and

2. Physical damage to vehicles especially if injuries to humans is involved. Most of the impacts would appear to have only a local effect on the transportation system.

Further, controversies may arise concerning the choice of particular routes to be undertaken in the execution of some BAAPs. Here the concern of residents and businessmen located on abbutting properties, or otherwise affected, is locationally specific and may be expressed in terms of objections to that route, demanding that another in the region

Examples of Typical Detailed Attributes.

DISRUPTIONS IN HIGHWAY TRAFFIC FLOWS

A.

This attribute is defined to be a delay in traffic flow along a certain highway or the rerouting of traffic from one highway to another (detour).

B.

The process producing this effect is a substantial increase or decrease in the number of vehicles passing by a certain point on the route per unit time, or a substantial decrease in the velocity of travel past a certain point.

C.

The effect is caused (a) by a change in the intensity of traffic flow resulting from a BAAP (e.g., a military convoy passing along a highway could cause a traffic jam), or (b) by damage to some traffic facility resulting from a BAAP (e.g., a military convoy could damage the road surface along which it passes), or (c) by damage to a vehicle caused ultimately by a BAAP.

D.

Disruptions in the traffic flow can cost people more money for a trip (financial costs), can cause people to miss appointments or to become irate (social costs), or can delay deliveries, or can affect one or more of the other environmental attributes (physical damage to traffic facilities, damage to vehicles or injuries to humans, or increased air pollution).

DETAILED ATTRIBUTE WITHIN TRANSPORTATION
CONTRIBUTING TO ROAD TRANSPORTATION

PHYSICAL DAMAGE TO RAIL TRAFFIC FACILITIES

A.

This attribute is defined to be damage to a specific rail facility such as a crossing sign, a switch, or a bridge.

B.

The process producing this effect is not readily identifiable.

C.

This effect can be caused directly by a BAAP or can be caused indirectly by a disruption in traffic flow resulting from a BAAP, or by a train or other accident due to a BAAP.

D.

Physical damage to rail traffic facilities costs the railroad company money to repair the damage and can affect one or more of the other environmental attributes (disruption in rail traffic flows; damage to trains or injuries to humans; or even disrupted water flows, by closing culverts under a damaged track).

DETAILED ATTRIBUTE WTHIN TRANSPORTATION
CONTRIBUTING TO RAIL TRANSPORTATION

MODIFICATION OR EXTENSION OF WATER TRAFFIC FACILITIES

A.

This attribute is defined to be the construction of new or the modification of existing water traffic facilities, necessitated by conditions resulting from some BAAP.

B.

The process producing this effect is not readily identifiable.

C.

The causes of this effect cannot be stated in general terms since they are heavily dependent on the BAAP in question and on the layout and capacity of the facility.

D.

Modification or extension of water traffic facilities will certainly be fairly costly to the public, but beyond this general statement it is impossible to make any definite predictions. The new facilities will generally be designed by others and, since they will not be designed or constructed by Army personnel, their environmental impact must be evaluated by others.

DETAILED ATTRIBUTE WITHIN TRANSPORTATION
CONTRIBUTING TO WATER TRANSPORTATION

be chosen. These controversies are related to the land use pattern of a region and to the socio-economic characteristics of the population in the affected neighborhoods, in addition to the usual traffic characteristics of the transportation facilities involved.

Selected Ramification Remarks and Mitigation Procedures. The following is an example of ramifications and mitigation concerning the construction activity *stumping.*

Ramifications: The principal effect of stumping on any nearby transportation link would derive from the use of explosives to do the stumping. Explosives produce much noise and dust which may cause traffic jams on any nearby transportation link. However, the diminution of the volume of sound with increasing distance from the typically small charges so used implies that the noise from this type of explosion will not be unacceptably large more than two miles from the construction site. Thus it seems reasonable to conclude that, in most cases, the use of explosives for stumping will not have much effect on any of the components of a transportation system located more than two miles from the site of the BAAP. Explosions at sites substantially nearer than two miles to any component of a transportation system may well endanger the facilities of that system or vehicles or passengers using it or the facilities of another system (the water supply system, the sewage system, the electric power system, etc.). It would further be noted that traffic jams resulting from repair of damage caused by explosions usually produce an increased level of air pollution in the adjacent area and will occasionally produce damage to transportation facilities or accidents to vehicles and injuries to humans. Since damage to transportation facilities or accidents to vehicles or injuries to humans are the random results of traffic jams, and therefore impossible to predict beforehand, they have not been indicated.

Mitigation: To the greatest extent possible, the transportation system used. This effect need not cipally during those parts of the day when traffic on any affected highway (or rail line or air corridor or waterway) is fairly light.

The following is an example of ramifications and mitigation concerning the construction activity *brush removal.*

Ramifications: The principal effect on a nearby highway system from removing brush from the site area would derive from the overuse of part of the highway system by vehicles transporting brush to a disposal area, thereby causing a traffic jam on the affected highway. Traffic jams usually produce an increased level of air pollution in the adjacent area and will occasionally produce damage to transportation facilities or accidents to vehicles or injuries to humans. Since damage to transportation facilities or accidents to vehicles and injuries to humans are random results of traffic jams, and therefore impossible to predict, they have not been indicated in this analysis.

Mitigation: When removal of brush must be done by trucks over public highways, the effect of such removal on the highway system can be mitigated by performing the removal during times of light traffic on the highway system (such as during the middle of the day for a highway used extensively by commuters).

The following is an example of ramifications and mitigations concerning the activity *raw materials delivery.*

Ramifications: It is unlikely that deliveries of raw materials to Army construction sites will cause much of a disruption in traffic flow or traffic jam in the transportation system used, since such deliveries can be and usually are spaced over a period of at least a number of days. However, it is conceivable that such deliveries could cause minor traffic jams, (associated with an increased level of air pollution) in the transportation system used. This effect need not have a major impact, if sufficient access roads are used.

Mitigation: Raw materials should be delivered when traffic on the transportation system used is light (such as during the middle of the day on a highway used extensively by commuters).

5 CONCLUSIONS

The D A Environmental Impact Study is an in-depth study to develop systematic procedures that can be used by Army personnel at all levels to prepare and review environmental impact assessments and statements for all Army programs. Given the appropriate input information for a subprogram, the computer-aided system developed will output environmental impact assessment information which includes:

1. A comprehensive list of potentially impacted environmental attributes. These impacted attributes

could include detailed, review level, or controversial attributes. Additional technical information regarding the attributes can be obtained from the computer, if desired. For example, for the detailed attributes, the following standardized information is being stored in the computer for easy access:

a. Definition of the attribute;

b. Information on how the attribute might be affected or influenced by Army actions;

c. Information on the source of the effect or the pollutant;

d. Information on how the effect on the environmental attribute might affect other biophysical and socio-economic attributes, i.e., interaction with other environmental attributes.

2. A need to consider scale which provides guidance on the degree of importance and the probability of impact on environmental attributes by the BAAP.

3. Information on known abatement and mitigation techniques and their effectiveness.

4. In addition, applicable environmental laws, regulations, and standards keyed to the impacted environmental attributes. (Details will be included in the forthcoming report as mentioned in the foreword).

This computer-aided environmental impact assessment system along with the information provided in this report can be used by the facility engineers, Corps districts, or divisions for preparing environmental impact assessments or statements in-house. Alternatively, if these assessments or statements are prepared by an outside consultant, the information could considerably reduce the cost of preparing such assessments or statements. In addition, the breadth of environmental information provided by the system would allow truly comprehensive and in-depth statements to be prepared.

This phase of the study covers the construction functional area only. As mentioned previously, other functional areas will be studied in later phases. Field testing of the system will commence immediately with the initial presentation of the system at the upcoming environmental impact assessment workshops sponsored by OCE presented by CERL and OCE personnel. Field testing will be coordinated with OCE. Feedback from the users will be utilized for refinement and modification of the system.

In addition to the development of other functional areas of Army activities and field testing of construction functional areas, assessment procedures and quantification techniques within a technical specialty need to be refined. More precise identification of potential environmental impacts will be made as additional data from Army installations are added to the data base.

As mentioned previously, EIA or EISs should not be prepared in mechanical compliance with NEPA, nor should the agencies make the writing of EISs a form of bureaucratic gamesmanship. The preparation of EISs and EIAs should serve as a tool for bringing into analysis and the decision-making process environmental considerations, which are sometimes referred to as the third dimension in decision making. The first and second dimensions would be the considerations of economics and mission accomplishment. The EIS should never be used to meet the needs of the agency's preconceived program nor simply to satisfy the procedural requirements of NEPA in order to protect the agency from legal action. The environment must be considered from initial project discussions through real-time operation. Consequently, no one manual or computer system will be able to completely address the environmental dimension. Active education of the decision-maker must accompany any system design so that the officials truly consider the environmental consequences of this action. To realistically address this issue, simultaneous efforts mst be undertaken to:

1. Develop operational user manuals for field personnel currently lacking adequate guidance.

2. Research new cost-effective assessment procedures which will improve on the quality of Army environmental impact assessments and statements.

3. Educate field personnel as to the requirements of NEPA and potential problems of lackluster compliance with the law. Environmental impact workshops can best accomplish this task.

4. Train already environmentally aware Army personnel to apply new and existing techniques for minimizing or abating adverse environmental impacts associated with their Army activities. Discipline-oriented environmental workshops could accomplish this task.

5. Staff and fund environmental operational programs at the field and staff level so that program implementation can be accomplished.

This report summarizes CERL's efforts to develop a systematic evaluation procedure for identifying potential environmental impacts associated with Army programs. We must now follow through with a rigorous education and training program if we are to succeed in bringing the environmental considerations into the decision-making process.

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ABBREVIATIONS

BAAP	Basic Activities Associated with Implementing Army Programs
CERL	Construction Engineering Research Laboratory
EIS	Environmental Impact Statement
EIA	Environmental Impact Assessment
EICS	Environmental Impact Computer System
NEPA	National Environmental Policy Act
TAG	The Adjutant General
DOD	Department of Defense
DA	Department of the Army
OCE	Office, Chief of Engineers
DALO-INE	Deputy Chief of Staff for Installations, Environmental Office
DCSLOG	Deputy Chief of Staff for Logistics
CELDS	Computerized Environmental Legislative Data System
OCRD	Office, Chief of Research and Development
TRADOC	Training and Doctrine Command
RDT&E	Research, Development, Test & Evaluation
CEQ	Council on Environmental Quality
OM&R	Operation, Maintenance & Repair
CONUS	Continental United States
BCT	Basic Combat Training
AIT	Advanced Individual Training
BUT	Basic Unit Training
AUT	Advanced Unit Training
ORT	Operational Readiness Training
PEMA	Procurement of Equipment and Missiles, Army
DSA	Defense Supply Agency
AMC	Army Materiel Command
ASPR	Armed Services Procurement Regulations
TACOM	Tank - Automotive Command
WECOM	Weapons Command
MUCOM	Munitions Command
EPA	Environmental Protection Agency
HUD	Housing and Urban Development